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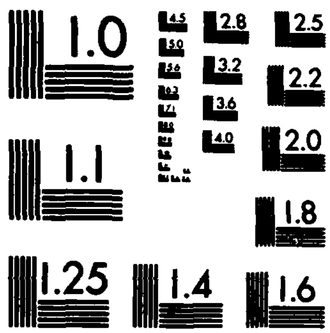

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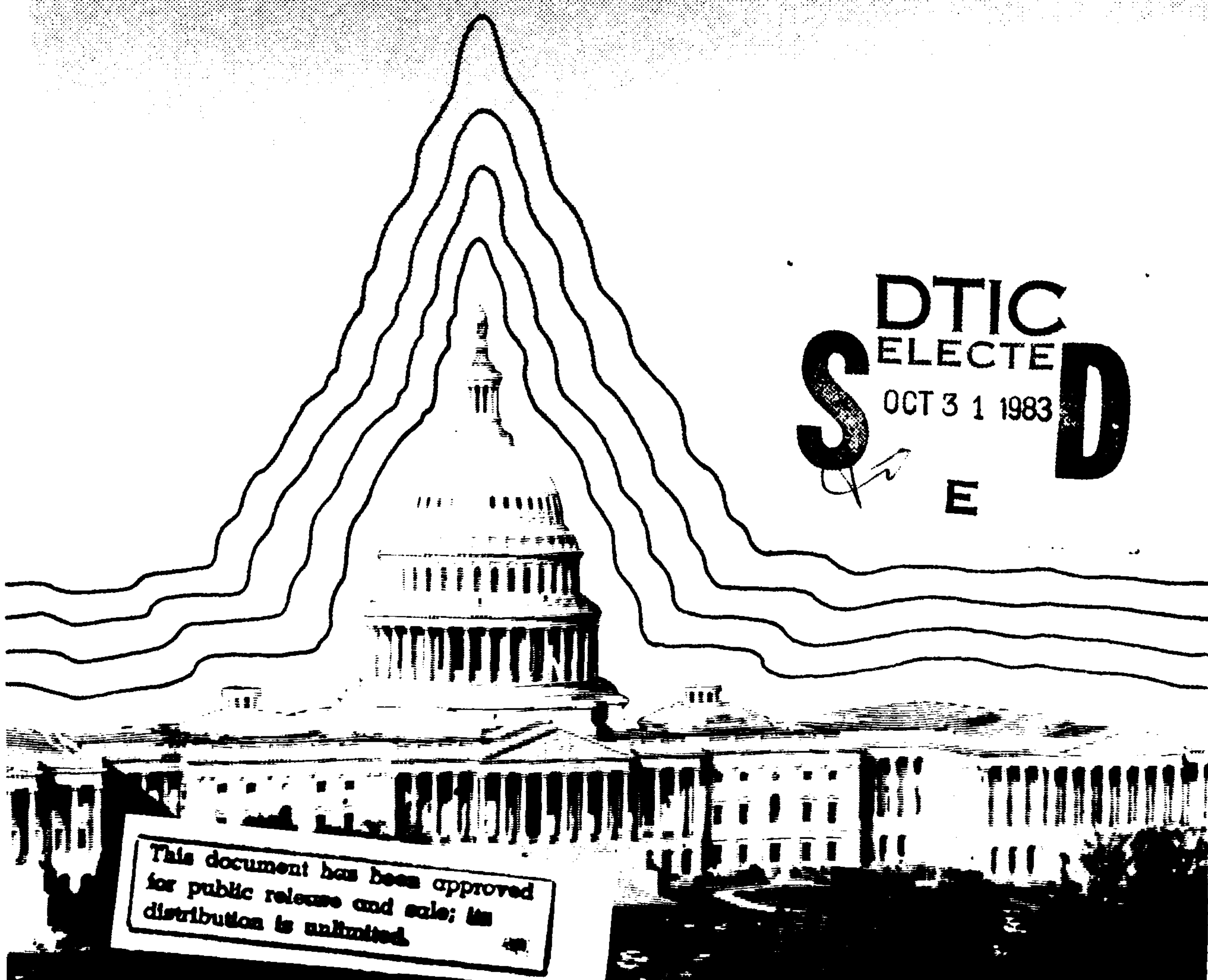

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METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY

APPENDIX E
RAW AND FINISHED WATER INTERCONNECTIONS AND REREGULATION

Department of the Army
Baltimore District, Corps of Engineers
Baltimore, Maryland

September 1983

REPORT ORGANIZATION*

METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY

Appendix Letter	Appendix Title	Annex Number	Annex Title
	Main Report		
A	Background Information & Problem Identification		
B	Plan Formulation, Assessment, and Evaluation	B-I	Water Supply Coordination Agreement
		B-II	Little Seneca Lake Cost Sharing Agreement
		B-III	Savage Reservoir Operation and Maintenance Cost Sharing Agreement
C	Public Involvement	C-I	Metropolitan Washington Regional Water Supply Task Force
		C-II	Public Involvement Activities - Initial Study Phase
		C-III	Public Opinion Survey
		C-IV	Public Involvement Activities - Early Action Planning Phase
		C-V	Sample Water Forum Note
		C-VI	Public Involvement Activities - Long-Range Planning Phase
		C-VII	Citizens Task Force Resolutions
		C-VIII	Background Correspondence
		C-IX	Coordination with National Academy of Sciences - National Academy of Engineering
		C-X	Comments and Responses Concerning Draft Report
D	Supplies, Demands, and Deficits	D-I	Water Demand Growth Indicators by Service Areas
		D-II	Service Area Water Demand & Unit Use by Category (1976)
		D-III	Projected Baseline Water Demands (1980-2030)
		D-IV	Potomac River Low Flow Allocation Agreement
		D-V	Potomac River Environmental Flowby, Executive Summary
		D-VI	PRISM/COE Output, Long-Range Phase
E	Raw and Finished Water Interconnections and Reregulation	E-I	Special Investigation, Occoquan Interconnection Comparison
F	Structural Alternatives	F-I	Digital Simulation of Groundwater Flow in Part of Southern Maryland
G	Non-Structural Studies	G-I	Metropolitan Washington Water Supply Emergency Agreement
		G-II	The Role of Pricing in Water Supply Planning for the Metropolitan Washington Area
		G-III	Examination of Water Quality and Potability
H	Bloomington Lake Reformulation Study	H-I	Background Information
		H-II	Water Quality Investigations
		H-III	PRISM Development and Application
		H-IV	Flood Control Analysis
		H-V	US Geological Survey Flow Loss and Travel Time Studies
		H-VI	Environmental, Social, Cultural, and Recreational Resources
		H-VII	Design Details and Cost Estimates
		H-VIII	Drawdown Frequency and Yield Dependability Analyses
		H-IX	Bloomington Future Water Supply Storage Contract
		H-X	Novation Agreement
I	Outlying Service Areas		

*The Final Report for the Metropolitan Washington Area Water Supply Study consists of a Main Report, nine supporting appendices, and various annexes as outlined above. The Main Report provides an overall summary of the seven-year investigation as well as the findings, conclusions, and recommendations of the District Engineer. The appendices document the technical investigations and analyses which are summarized in the Main Report. The annexes provide detailed data or complete reports about individual topics contained in the respective appendices.

METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY

APPENDIX E

RAW AND FINISHED WATER INTERCONNECTIONS
AND REREGULATION

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APPENDIX E

RAW AND FINISH WATER INTERCONNECTIONS AND REREGULATIONS

This appendix examines three of the alternatives considered in the early-action phase of study - namely raw water interconnections, finished water interconnections, and reregulation. The information provided in this document has been somewhat condensed from the investigations described in the August 1979 Progress Report. Project costs, however, have been updated to October 1981 price levels to facilitate comparison with other alternatives which were analyzed later in the long-range study phase.

RAW WATER INTERCONNECTIONS

The major water study agencies that serve the Metropolitan Washington Area are: the Washington Aqueduct Division (WAD); the Washington Suburban Sanitary Commission (WSSC); and the Fairfax County Water Authority (FCWA). The primary raw water supply sources for these agencies are: the Potomac River; the Patuxent River (Triadelphia and Rocky Gorge Reservoirs), and the Occoquan Creek (Occoquan Reservoir). Table E-1 lists in terms of percentages the relative amounts of water obtained from each source according to water supply agency. As can be seen from Table E-1, the Aqueduct and the Commission satisfy the majority of their service area demands from the Potomac River. Before 1982, the FCWA did not place any demand on the Potomac River. In 1982 however, upon completion of its Potomac River Treatment Plant, the Authority started withdrawing from the Potomac and will eventually shift much of its Occoquan demand to the Potomac, saving Occoquan water for low flow situations. For all practical purposes therefore, it appears that by the mid-1980's the Potomac River will become the principal raw water source for these agencies.

During the course of a normal water year, flows in the Potomac River would be sufficient to satisfy this large demand. A problem arises, however, when low flow conditions exist in the Potomac River and the volume of flow is not adequate to meet the area's needs. Under a condition such as this, the demand placed on the local offstream reservoirs would be increased in an effort to reduce the shortage created by low Potomac flows. In the final analysis, this would lead to a more rapid drawdown of the reservoirs than would otherwise be encountered. If the drought conditions persist for any extended period of time (carried over into the following summer), then in addition to the river being extremely low, the reservoir storage capacities would be stretched to their limit.

One water supply alternative that could be employed as a means of averting the situation just described is a raw water interconnection. A raw water interconnection system is shown in schematic form in Figure E-1. There are four basic components necessary for a raw water interconnection system; a river or stream source of water supply, an off-stream reservoir, water treatment plants for both reservoir and river supply sources where available, and a pipeline and pump system connecting the two sources. The primary purpose of a raw water interconnection is to conserve stored water during high flow periods for use in low flow periods. During times of excess flow in the major river source, raw water would be withdrawn and transferred to the reservoir treatment plant or the offstream reservoir via a pipeline. Conversely when low flows are experienced in the major river source, augmentation may be achieved by transferring water from the reservoir through the pipeline to the major river source water treatment plant. In this manner, optimum use could be made of both the river water supply source and the reservoir storage.

TABLE E-1

PERCENT OF WATER OBTAINED FROM EACH SOURCE
1981

Agency	Source	Percentage
WAD	Potomac River	100
WSSC	Potomac River	75
	Patuxent River	25
FCWA*	Occoquan Creek	100

* FCWA began shifting some of its normal (non-drought) withdrawals to the Potomac in mid-1982.

The analysis described in this section investigates the potential for constructing raw water interconnections between the Potomac River (or Shenandoah River) and existing major area water supply reservoirs on Goose Creek, Occoquan Creek, and the Patuxent River.

EVALUATION METHODOLOGY

DESIGN AND COST

Conceptual designs and cost estimates were needed to perform a preliminary screening of the alternative raw water interconnections. This information was generated by applying typical pipeline design criteria and preparing cost estimates based on standardized relationships. The following paragraphs present the specific design and cost methodology for each of the main components of a raw water interconnection.

Pipelines

The pipeline linear cost was calculated as a function of the pipe diameter. The latter was calculated by the following equation:

$$D = \frac{Q \times 1.547}{V \times 12}$$

where D is the preliminary pipe diameter in inches, Q is the pipe design flow in millions gallons per day (mgd), and V is the pipe flow velocity in feet per second (fps). Since the Virginia State Water Control Board normally allows flow velocities of 2.5 to 15 fps, an average value of 6 fps was used throughout the analyses. The final pipe diameter was determined by rounding up the preliminary value to one of the following standard pipe diameters: 8, 12, 14, 16, 18, 20, 24, 30, 36, 42, 48, 54, 66, 72, 84, 96, 108, 120, and 132 inches.

The Linaweaver equation listed below was used to calculate the estimated construction cost of a pipeline constructed in overburden including all associated costs such as site preparation, excavation, delivered pipe sections, installation, backfill, etc.

$$y = \text{[illegible]}.11 \times D^{1.29} \times ENR$$

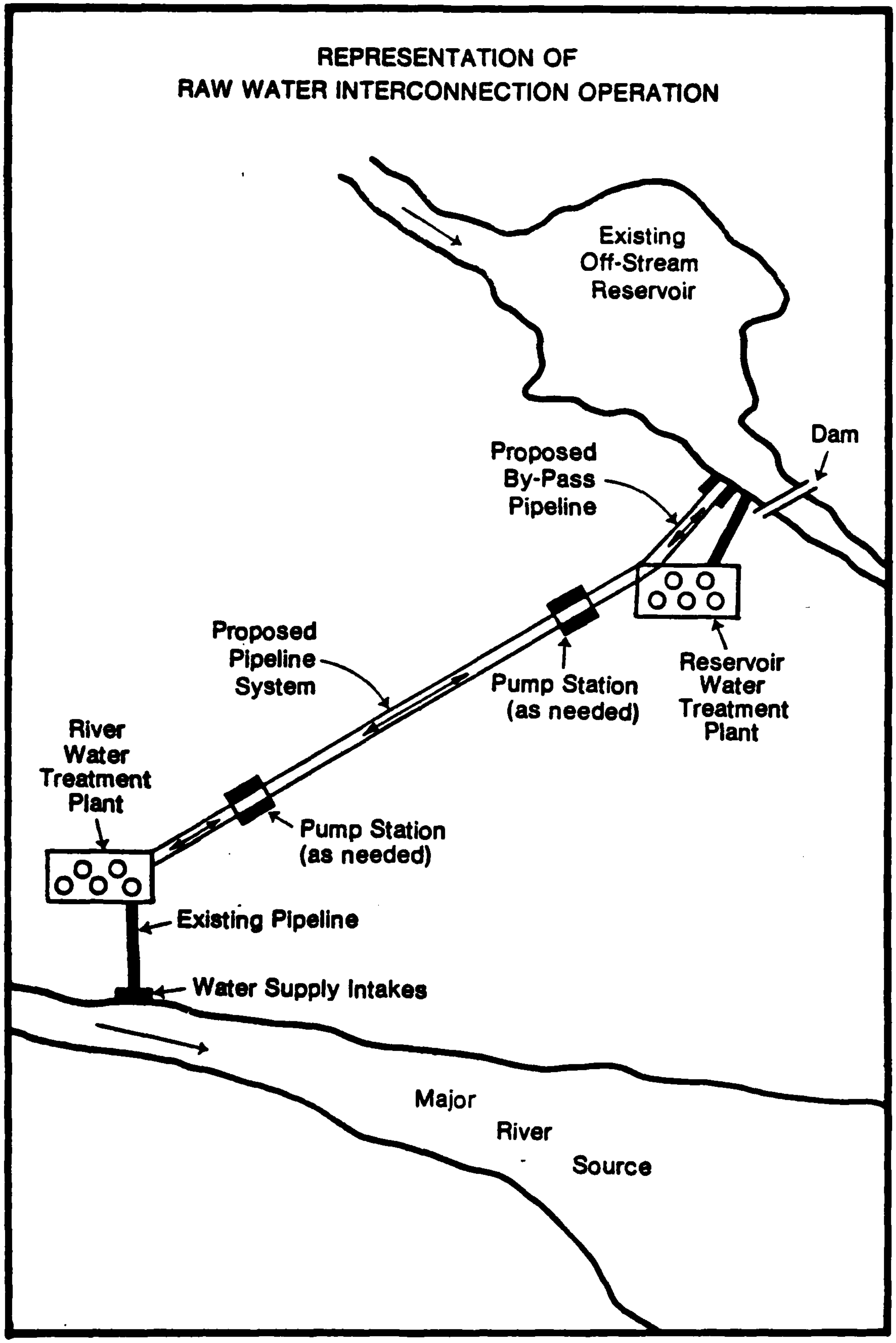
REPRESENTATION OF
RAW WATER INTERCONNECTION OPERATION
Existing
Off-Stream
Reservoir
Dam
Proposed
By-Pass
Pipeline
Proposed
Pipeline
System
Pump Station
(as needed)
Reservoir
Water
Treatment
Plant
River
Water
Treatment
Plant
Pump Station
(as needed)
Existing Pipeline
Water Supply Intakes
Major
River
Source

Figure E-1

In this equation, y is the pipeline cost per linear foot (Oct 1981 price levels) including a contingency of 15%, D is the pipeline diameter in inches, and ENR is the Engineering News Record Construction Cost Index escalation from December 1977 to October 1981 (3672/2669 = 1.38). In comparison to other similar cost estimating equations, the Linaweaver equation generates the greatest linear pipeline costs and therefore provides a conservative cost estimate that accounts for most contingencies.

Pump Stations and Intakes

The estimated construction cost of a pump station was related to the total horsepower. The latter value is a function of the design flow and the total head, which consists of the static head and friction head. The static head is merely the difference between the maximum and starting elevations of the pipeline route. The friction head loss was calculated by the Hazen-Williams equation:

$$H_f = \frac{V^{1.85} \times L}{(1.318C)^{1.85} \times R^{1.17}}$$

where H_f is the friction head in feet, V is the velocity in fps, L is the total pipeline length in feet, C is the Hazen-Williams coefficient, and R is the hydraulic radius in feet. Assuming that concrete pipe was used, a C value of 150 was selected, which includes a 15% factor to account for aging of the pipe.

The total horsepower of the pumping station was then calculated by the following equation:

$$HP = \frac{Q \times H \times 62.4}{550 \times e}$$

where HP is horsepower, Q is the flow in cfs, H is the total head (static and friction) in feet, and e is the combined efficiency of the pump and motor (0.64).

There is no precise relationship between horsepower and pumping station cost; however, it was believed that a curve developed by Malcom Pirnie, Inc. (Figure E-2) was reliable enough for preliminary screening purposes. The estimated cost included such items as site preparation, pumping station building, mechanical and electrical equipment, contingencies, and contractor overhead and profit. The total estimated pumping station construction cost in October 1981 dollars is calculated by multiplying the unit cost/horsepower value taken from the curve times the total horsepower. It should be noted that two pumping stations are required for reversible pipeline routes.

The design and cost of intake structures are very dependent on site conditions and since a detailed analysis was not required for screening purposes, it was decided to use a generalized cost in the range of $350,000 to $550,000 per structure.

Land

Real estate easements are needed for a pipeline for both construction and access. Typical easement widths for various sizes of pipe were developed by Henningson, Durham, and Richardson for the Bi-County Water Supply Study. These widths, which are listed on Table E-2, are based on stable soil conditions, open trench excavation with no sheeting, and 3.5 to 4 feet of cover over the pipe.

Figure E-2

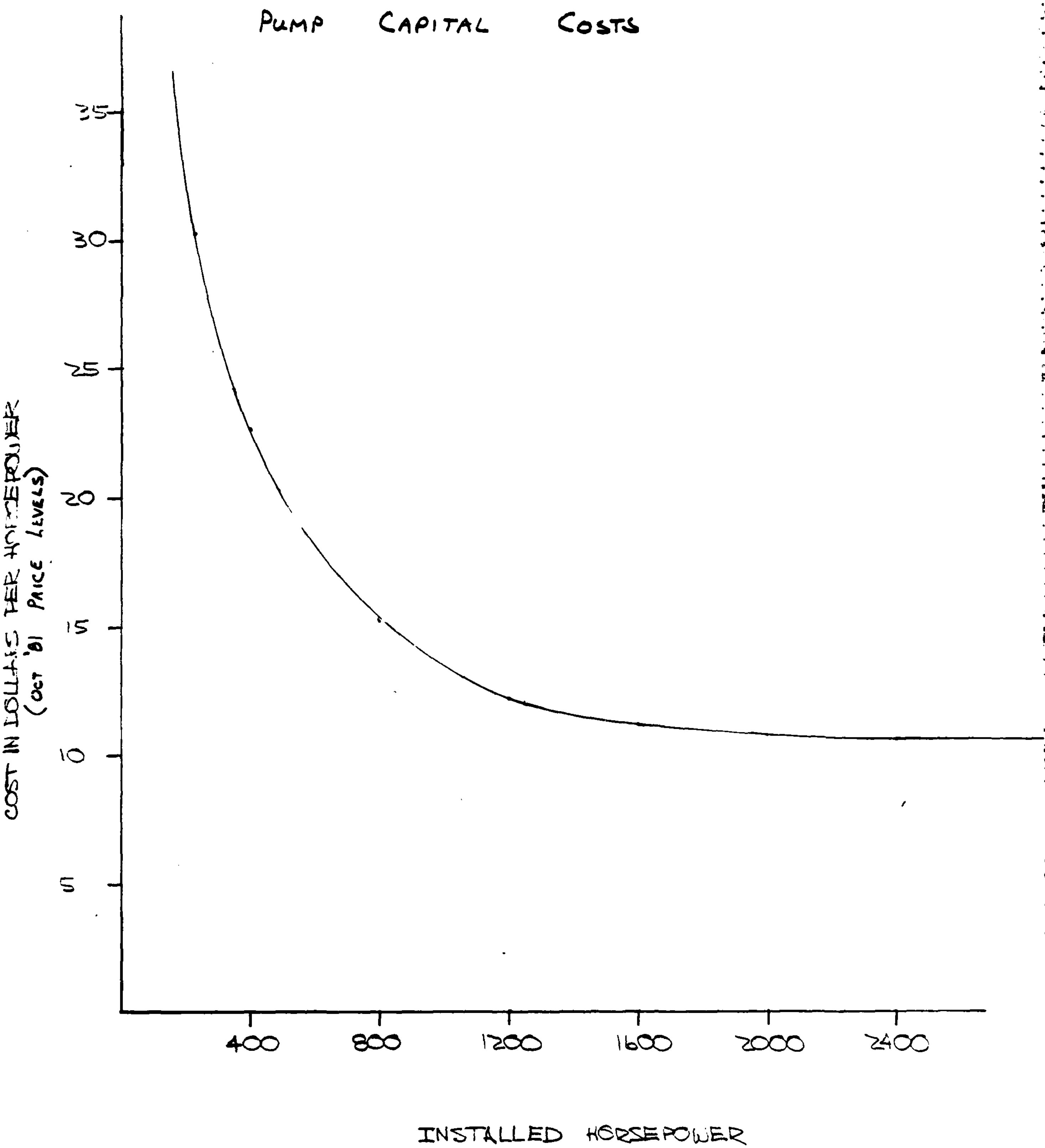
PUMP CAPITAL COSTS
COST IN DOLLARS PER HORSEPOWER
(OCT '81 PRICE LEVELS)
35
30
25
20
15
10
5
400
800
1200
1600
2000
2400
INSTALLED HORSEPOWER

TABLE E-2

RECOMMENDED EASEMENT WIDTHS FOR WATER MAINS

Size of Pipe	Easement Width (ft)
8" - 12"	24
14" - 16"	30
18" - 24"	35
30"	40
36" - 42"	55
48" - 72"	65
84" - 96"	80
108" - 120"	90

Total land costs were computed by using the widths listed above and assuming an average land value of $18,000 per acre.

Operation and Maintenance

The final step in evaluating the costs of each pipeline route was estimating the operation and maintenance (O&M) costs. The pumping station energy costs, which constitute most of the O&M costs, were computed by the following equation:

$$\text{Energy Costs} = \text{HP} \times .746 \times \text{Energy Cost} \times 24$$

where Energy Cost is in $/day, HP is the pump station total horsepower, Energy Cost is the $/killawatt hours (KW-HR) cost of the electricity. The above equation assumes the station is operated continuously over the 24 hour period. To account for maintenance costs the following relationship should be used.

$$\text{Total O\&M Cost} = 1.08 \times \text{Energy Cost}$$

ENVIRONMENTAL ANALYSIS

In addition to the development of preliminary cost data, environmental impacts were defined for each of the proposed raw water interconnection route alignments. In undertaking an assessment of impacts associated with potential interconnections the main objective was to identify the significant impacts associated with each of the routes. By assessing the range of ways in which the various routes affect the natural, social, and economic environmental in the MWA, it was possible to identify significant impacts which would be encountered.

In order to identify and measure the likely impacts of proposed actions, an appraisal of existing conditions in the MWA was required. This task was accomplished by an interdisciplinary team representing the following diverse areas of specialization: archaeology, biology, economics, community and recreational planning, engineering, geography and geology, public administration, and real estate. It was felt that a team comprised of members representing a wide range of disciplines would best he able to develop a comprehensive assessment of the complex natural and cultural environment.

The team relied on four major sources of information for the impact assessment: reports and publications; photo-revised USGS 1:24,000 topographic sheets; 1977 aerial photographic coverage of the study area; and field reconnaissance.

Existing reports including master plans, local and regional plan proposals, land use zoning maps and other published materials were utilized so that local preferences for planning would receive ample consideration in the assessment process.

Revised 1:24,000 United States Geological Survey topographic maps were useful in assessing the various routes with respect to the geographic areas that could potentially be affected. Transportation systems, utilities, drainage networks, topographic characteristics, and cultural information were extracted from this source.

The variance in use of land adjacent to a proposed project was considered an important determinant in the assessment and evaluation of impacts. For this reason, aerial photography provided a means for the study team to delineate a wide range of land uses. These various land uses were differentiated by examining the variety of tones, patterns, and spatial arrangements of ground objects. The study team used a 1:24,000 uncontrolled photo-mosaic that was constructed using 1977 aerial photos with stereoscopic viewing capability. For the Potomac-Occoquan interconnections 1:24,000 non-stereo coverage (1977) was used.

Further refinement of the information was conducted through field reconnaissance by the study team. These field surveys enabled team members to obtain a view of the areas under study and observe recent development not shown on the topographic maps or the more recent photographic coverage.

With the aid of these sources, raw water interconnection were identified on topographic maps and outlined on transparant overlays using recommendations set forth in local reports and publications. Land use overlays were then constructed through photographic interpretation of ground features. Specific land use categories were developed for areas devoted to residential, agricultural, commercial-industrial, public, recreational, forested, transportation, and utility uses. Drainage features were also delineated.

The measurement of potential impacts associated with raw water interconnections was taken primarily from the photomosaics. Where applicable, a predetermined "impact corridor" was developed since it was recognized that areas adjacent to the proposed routes could be affected to varying degrees during and after construction of the projects. This "impact corridor" was used to quantify the amount of lands, road, and utilities that could be affected by the various interconnection routes.

The factors used in the assessment of the raw water interconnection routes are described in Table E-3 and described in the following paragraphs.

Ecological

Total miles of Pipeline. Knowledge of pipeline length provides appreciation for the relative magnitude of impacts that may be associated with particular routes.

Number of Stream Crossing. The number of stream crossings is the total number of times a pipeline traverses a stream to a point along its length.

TABLE E-3
RAW WATER INTERCONNECTIONS: IMPACT FACTORS CONSIDERED

- ECOLOGICAL
  - Total Miles of Pipeline
  - Number of Stream Crossings
  - Number of Major 100 year Floodplain Crossings
  - Total Miles along Major Stream Valleys
  - Potential Critical Wildlife Habitat Affected
  - Potential Threatened or Endangered Species Affected
  - Miles Through a Adjacent to Farmland Habitat
  - Miles Through a Adjacent to Forest Habitat
- SOCIAL
  - Total Miles Along Transportation Routes
    - Dual
    - Primary
    - Secondary
    - Other
  - Number of Intersections with Transportation Routes
    - Dual
    - Primary
    - Secondary
    - Railroad
  - Total Miles Along Existing Utilities
    - Water
    - Gas
    - Electric
  - Number of Intersections with Utilities
    - Water
    - Gas
    - Electric
  - Number of Known Cultural Resource Areas
  - Potential Cultural Resources Areas
  - Miles Adjacent to Specific Land Use type:
    - Agricultural
    - Woodlands
    - Commercial/Industrial
    - Public
    - Recreational
    - Residential
  - Number of Residences Affected
- REAL ESTATE
  - Total Real Estate Costs
  - Land Cost
  - Improvements
  - Severance
  - Relocation
  - Number of Owners Affected
- OTHER CONSIDERATIONS
  - Floodplain Management
  - Treatment of EO 11988 in Planning Process

Number of Major 100 Year Floodplain Crossings. The number of 100 year floodplain crossings is the total number of times a pipeline traverses the designated 100 year floodplain at a point along its length.

Total Miles Along Major Stream Valleys. Stream valleys are important natural features that lend themselves to a variety of recreational uses as well as providing aesthetic amenities, natural drainage, critical habitat areas, and fertile lands for agriculture. Construction activities within a stream valley could produce adverse impacts such as accelerated erosion and sedimentation resulting in water quality and ecologic problems. The total number of miles along stream valleys were recorded where an interconnection paralleled a major stream within 500 feet on either side.

Potential Critical Wildlife Habitat Affected. Within the MWA there remain large non-urbanized areas that support a diverse wildlife population. These areas are critical to the survival of many plant and animal species, given the expanding nature of the MWA.

Potential Threatened or Endangered Species Affected. Some species of plants and animals have been subjected to either natural or man-made conditions that have caused a significant decline in their numbers. These events have led to Federal recognition and the resultant action of creating categories for protection of those species listed as threatened or endangered. The endangered species program, administered by the Department of Interior, seeks to maintain these species by extending the force of the law to protect existing numbers and by guaranteeing sufficient reproduction by preserving natural habitat.

Miles Through or Adjacent to Farmland Habitat. Portions of the metropolitan area still remain in agricultural use including cropland, pastureland and inactive fields. Agricultural areas form an ecologically unique and rather large portion of the underdeveloped land in the region. Impacts should be greatest in these areas during the period of pipeline construction, however, would be greatly reduced subsequent to construction activities.

Miles Through or Adjacent to Woodland Habitat. In constructing pipelines through wooded areas, some trees and other vegetation will have to be removed from the rights-of-way resulting in a temporary impact on the terrestrial plant and animal communities existing in the pipeline corridor. However, with the pipeline right-of-way transversing forest land, an edge is created where low herbaceous and woody plant growth meet with forest vegetation. This merged edge of two diverse plant communities will often produce or attract more kinds and numbers of animals than would occur in either habitat type alone.

Social

Total Miles Along Transportation Route. Existing transportation routes serve as potential pathways, providing in many cases a relatively graded and easily accessible means for the construction and maintenance of a raw or finished water pipeline. In addition, locating a pipeline within the right-of-way or parallel to a roadway reduces disturbances to the natural and/or cultural environment as compared to pipelines crossing large tracts of land without regard to existing rights-of-way. On the other hand, the paralleling of transportation routes may cause short-term traffic disruption, particularly during the construction stages of a pipeline. For the purposes of this study, miles along transportation routes is defined as the total length that a particular pipeline parallels, within 500 feet on either side of each of the following types of transportation routes:

a. Dual Road - A major heavy duty four lane roadway usually serving local and commercial traffic.

b. Primary Road - A major two lane heavy duty roadway usually serving local and commercial traffic.

c. Secondary Road - A minor two lane roadway maintaining light and local traffic and primarily serving residential areas.

d. Other roadways - An unimproved minor one or two lane roadway maintaining light local traffic.

Number of Intersections with Transportation Routes. During the construction phase, where pipelines cross major transportation routes, the potential for traffic disruption may be great. Likewise, the junctures with transportation routes may serve as valuable access points to a pipeline during operation and maintenance as well as during construction. The number of intersections is defined as the number of points where a pipeline traverses a transportation route or refers to the points where an interconnection route meets from any direction but does not cross a roadway or railroad.

Total Miles Along Existing Utilities. Major utility rights-of-way potentially can provide a favorable corridor in which to align interconnection pipeline. The major advantage afforded by the use of these corridors is the overall reduction in social and environmental disruption during their construction, operation, and maintenance. Although longitudinal occupation of utility rights-of-way is not always desirable as it encumbers future use of the right-of-way by the respective utility, longitudinal occupation may be considered upon written request on an individual installation basis. Most utility companies require that construction parallel their facilities at a proper distance, allowing easy and safe access for repair and servicing. In certain instances, as in the case of underground utilities (gas, petroleum), the condition might require use of additional lands, outside of the utility rights-of-way.

Intersections with Major Utilities. This is the number of crossings that a particular pipeline route makes with gas, water, and overhead transmission lines. In instances where a pipeline intersects, parallels and then departs from a major utility line, two intersections, one at the initial intersection and one at the departure point, were recorded for the purposes of this analysis. The same procedures would be required regarding permission to cross utilities as those discussed in the previous section.

Number of Known Cultural Resource Areas. The number of crossings transversing known sites and properties which are on the National Register and state inventory lists are in this category and include Historical Districts, properties, sites, structures, and objects. Known sites, properties, and objects are important as they reflect significant events and accomplishments of our culture and communities, nationally, statewide, and locally.

Potential Cultural Resource Areas. Potential cultural sensitivity areas within the MWA would include the number of pipeline crossings over cultivated farmlands, forests, major stream floodplains, stream crossings and parklands that have not been drastically disturbed. These minimally disturbed areas are within predictive cultural resources model areas for buried cultural resources because the Potomac, Patuxent, and Occuquan Rivers and their major tributaries are considered prime areas for prehistoric and historic exploitation and habitation. The destruction or partial loss of these potential cultural

resources would be an irretrievable loss to National, state, or local heritage if the above lands were altered prior to their evaluation and inspection for cultural resources.

Miles Adjacent to Specific Land Use Type. All of the proposed interconnection routes traverse or parallel land committed to different types of usage. A particular impact may be associated with a given use, depending upon the type and intensity of activity related to this use. Miles through or adjacent to a particular use may therefore be a significant indicator in assessing the relative impacts for decision-making. For the purposes of this assessment, each of the following land use categories was included in the impact measurement if it was determined to be within 500 feet on either side of the interconnection route.

a. Agricultural - Agricutural lands are those committed to use in the production of crops and livestock. The impacts result either from a temporary disruption of the land by physical contact with the construction activities or from a decrease in the amount of farmland available for use due to the physical barrier that the construction right-of-way could cause. The construction could physically impact crops currently planted as well as prevent the planting of new crops. In addition, wildlife inhabitating the pasture or cropland could be temporarily impacted until new vegetation can be reestablished. An increase in soil erosion can occur through rutting along the rights-of-way by heavy equipment or by the removal of ground cover. Land use planning and conservation practices, however, could help to rectify this situation.

b. Wooded Land - Although some economic loss of timber productivity will result from clearing for pipeline rights-of-way, these losses are expected to be minor as most of the wooded areas are located on properties in agricultural or private residential use. It is possible that potential losses of productive timber lands can be offset by converting portions of land into uses that would provide or equal higher return.

c. Commercial/Industrial - Commercial and industrial properties are those used for the sale of durable and non-durable goods and services as well as their storage including wholesale and retail outlets. A certain impact is the removal or alteration of existing commercial and/or industrial property or the alternative use of land that is suitable for commercial and industrial development. In most cases, land that can be put into commercial or industrial use must possess certain qualities. Slope, subsurface conditions, and local utility and transportation service must be amendable. To construct a pipeline could mean that existing land use patterns are changed either permanently or temporarily. These changes could therefore alter employment patterns and the opportunities available to the resident population for wholesale and retail trade. An area's economic base could be adversely affected and overall economic well being put in question.

d. Public - The public land use category generally includes schools, places of worship, hospitals, government buildings, and cemeteries. Impacts that can occur to public use property are not unlike those affecting residential, commercial, and industrial and in either the long or the short term. Relocation and construction impacts are the two most prominent impact categories associated with public use property. As opposed to impacts on residential property, the impacts to public use property are going to be felt intermittently as visitors go to and from the public facility. Jails and prisons are special categories to be considered; however, their overall incidences of occurrence are slight. Cemeteries are also specialized instances which pipelines routes should avoid. Careful consideration must be given to the need for relocation versus the adjustment of a proposed pipeline rights-of-way.

e. Recreational Land - Recreational lands are public and semi-public land used for outdoor recreation activities and include parks and campground areas. The impacts associated with a pipeline transversing recreational lands would result mainly from a decrease in the number of days available for use. This would occur from a lack of adequate accessibility to the area by local traffic disruptions during construction. There also exists the possibility of an aesthetic impact by any construction activity near a recreation parkland or nature area. Because of these concerns those routes which minimize disruption to recreational areas are performed.

f. Residential - Residential lands are those committed to uses including single, multiple dwelling and mobile home sites. The impacts of routing a large diameter underground water line through an established or emerging residential area can be temporary, lasting, adverse, or beneficial; but in any case, impacts are usually considerable. Property values could be affected by proximity to utility easements. In addition, temporary disruption to local vehicular traffic may cause minor inconvenience to a community.

After construction of the pipeline, the pipe and easement must be operated and maintained. Operation and maintenance are generally associated with adverse impacts. Should a section of pipe break, it then becomes necessary to unearth the failed pipe section by digging. This is disruptive to residential areas often bringing noise and air pollution, dust, glare, and vibration.

Number of Residences Affected. This category is meant to represent the total number of dwellings, excluding apartments and townhouses within 1,000 feet of either side of a proposed interconnection. These residences may experience, to varying degrees of intensity, impacts associated with the construction of a pipeline including noise, disruption of traffic patterns, and differing aesthetic qualities. In some cases, where an interconnection crosses individual properties, residential structures may require relocation.

Real Estate

Total Real Estate Costs. Total costs (Oct 81 prices) relate to the combined damages to land, improvements and severance costs associated with each route. These values provide enough rough and approximate figures of the real estate costs for comparative purposes.

Cost for Land. The market value for land along the proposed pipeline routes is approximated in millions of dollars. It varies according to the highest and best use of each property and is also influenced by the expanding market for developable land in the MWA. Land values along areas near the proposed rights-of-way were not considered to be adversely affected by the pipeline after the taking. Conversely, no increase in value is anticipated.

Values of Improvements Along Pipelines. Improvements values indicate the compensation due a property owner who must relocate his home or business from land purchased for the construction of a pipeline. Additional compensation awardable under Public Law 91-646 is not reflected in these figures. The values are approximate ones related to the length of pipelines paralleling roadways through variable land use types. Where pipeline routes travel cross-country, the number of improvements diminish as does their corresponding values. These estimates provide an indication of the relative value of structures involved in all potential pipeline routes.

Severance. Severance costs relate to the damages paid to a property owner should his land be crossed by a pipeline in such a fashion that use of the remainder is impaired. It is the damage to the part not taken, in the case of a partial taking, which arises by reason of the taking (severance) and/or the construction of the improvement in the manner proposed. The damage to the severed portion is evaluated in direct proportion to the diminution in value to the remainder. It is then added to the value of the direct taking of land and improvements. These costs would evolve for rights-of-way over private land where routes deviate from existing utility or highway easements. Keeping severance costs to a minimum would best benefit the needs of the project.

Relocation. Relocation costs were considered to be about $10,000 per move and in most of the prospective routes, 50% of the potential owners were projected for relocation. In several cases, a percentage greater than 50% was applied to the relocation costs.

Number of Owners Affected. Where project sites have been specifically identified, the number of owners has been given. This provides an indicator of administrative costs and complexity for real estate acquisition. Each purchase of a land interest involved mapping, appraising, preliminary and final title searching, negotiating, and closing which are ultimately costed separately. Generally speaking, the more tracts to be acquired, the higher the adminstrative costs and the greater the complexity of the project.

Other Considerations

This section will address the remaining impact concerns and identify how these concerns are being addressed in this study.

Flood Plain Management. On 24 May 1977, the President issued a comprehensive environmental message that was accompanied by Executive Order 11988, Floodplain Management. The new order recognizes the need not only to protect lives and property in the Nation's floodplains, but also to restore natural and beneficial floodplain values. Guidelines for implementing the executive order were issued by the Water Resources Council in January 1978 and were formulated to assist Federal agencies in developing procedures for compliance with the order.

Treatment of EO 11988 in the Planning Process. A delineation and quantification of stream valley crossings and stream valley segments paralleled by interconnection pipelines was undertaken as an initial step in response to the directive promulgated by EO 11988. The location of each stream valley is indicated for each route under consideration on the attached longitudinal profiles. Early in the planning process, it was recognized that the construction of the components under consideration would affect the natural and beneficial values afforded by streams and their floodplains. Recognition of this prompted including the number of 100-year floodplain crossings in the environmental impact assessment for the interconnection pipelines.

PRELIMINARY SCREENING OF ROUTES

ROUTE IDENTIFICATION

The first work task laid the basic groundwork for the development of a raw water interconnection scheme for the Metropolitan Washington Area by identifying potential raw water interconnection points and route alignments. This was achieved by researching previous reports that examined water supply alternatives for the MWA and

identifying those reports in particular which considered raw water interconnections alternative. As a results of these efforts, three reports were identified: (1) Water Supply Study for the Washington Metropolitan Area, prepared in 1974 by the consulting engineering firm of Black and Veatch for the Washington Suburban Sanitary Commission, District of Columbia, and the Fairfax County Water Authority; (2) Pumped Storage Project W-133, Montgomery County, Maryland, prepared in May 1975 by the Ralph M. Parsons Company for the WSSC; and (3) Water Supply and Allocation Planning Study for Northern Virginia, prepared in November 1977, by the Virginia State Water Control Board and the State Water Study Commission. Table E-4 lists the recommendations forwarded by these reports. In addition to the route alignments and sources identified by these reports, the Corps of Engineers, after preliminary review of this earlier work and through visual inspection of USGS 7.5 minute series topographic maps, identified two additional route alignments for the Potomac River to Occoquan Reservoir interconnection and recommended investigating one new interconnection between the Potomac River and Goose Creek Reservoir (Fairfax City) using two different route alignments. The additional recommendations are also presented in Table E-4 and Figure E-3 shows a schematic diagram of the potential raw water interconnections.

EVALUATION AND SCREENING

As a means of reducing the fourteen raw water interconnection route alignments to a more manageable number for planning purposes, an in-house assessment of environmental and economic impacts associated with the raw water interconnection routes was accomplished concurrently with an optimization analysis.

Environmental Analysis

The environmental impact assessment was accomplished by an interdisciplinary team, representing diverse areas of specialization. The team relied on four major sources of information for the impact analysis: existing reports and publications; photo-revised USGS 1:24,000 topographic quads; 1977 aerial photographic coverage of the study area; and field reconnaissance. "Impacts corridors" were identified for each pipeline and preliminary economic, social, and environmental impacts were quantified where possible and tabulated into impact assessment matrices. Tables E-5 thru E-7 presents numerically the impacts associated with the raw water interconnection routes, according to the aforementioned considerations. The following text also provides a descriptive evaluation of certain raw water interconnection for which numerical data was not developed in the environmental analysis.

Potomac River to Goose Creek (Routes #1 and #2)

Route 1, 4.5 miles in length, utilizes the valley of the Goose Creek. Construction of Route #1 would temporarily result in increased erosion, and sedimentation rates and concurrently disrupt the biology of the stream, its bed, and the immediate surrounding area. Any maintenance activities that would require exposure of the pipeline would have similar results. Secondly, Goose Creek has recently been designated a scenic river by the Virginia General Assembly for inclusion in the Virginia Scenic River System. The intent of the legislation (Scenic Rivers Act, Title 10, Chapter 15, Sections 10-175, approved April 4, 1970) provided for the assurance of the rivers designated as part of the system would be protected for their scenic, recreational, geological, fish and wildlife, historic,

TABLE E-4

PRELIMINARY ROUTE IDENTIFICATION
RAW WATER INTERCONNECTIONS

Originating Source	Agency	Proposed Point Sources Connected	# of Route Alignments Investigated
Black and Veatch (1974)	FCWA	Potomac River/Occoquan Reservoir	1
Ralph M. Parsons (1975)	WSSC	Potomac River/Patuxent River (Triadelphia)	4
	WSSC	Potomac River/Patuxtent River (Rocky Gorge)	4
Virginia State Water Control Board & State Water Study Commission (1977)	FCWA	Shenandoah River/Occoquan Creek (Broad Run)	1
Corps of Engineers	FCWA	Potomac River/Occoquan Reservoir	2
	City of Fairfax	Potomac River/Goose Creek Reservoir	2
			14

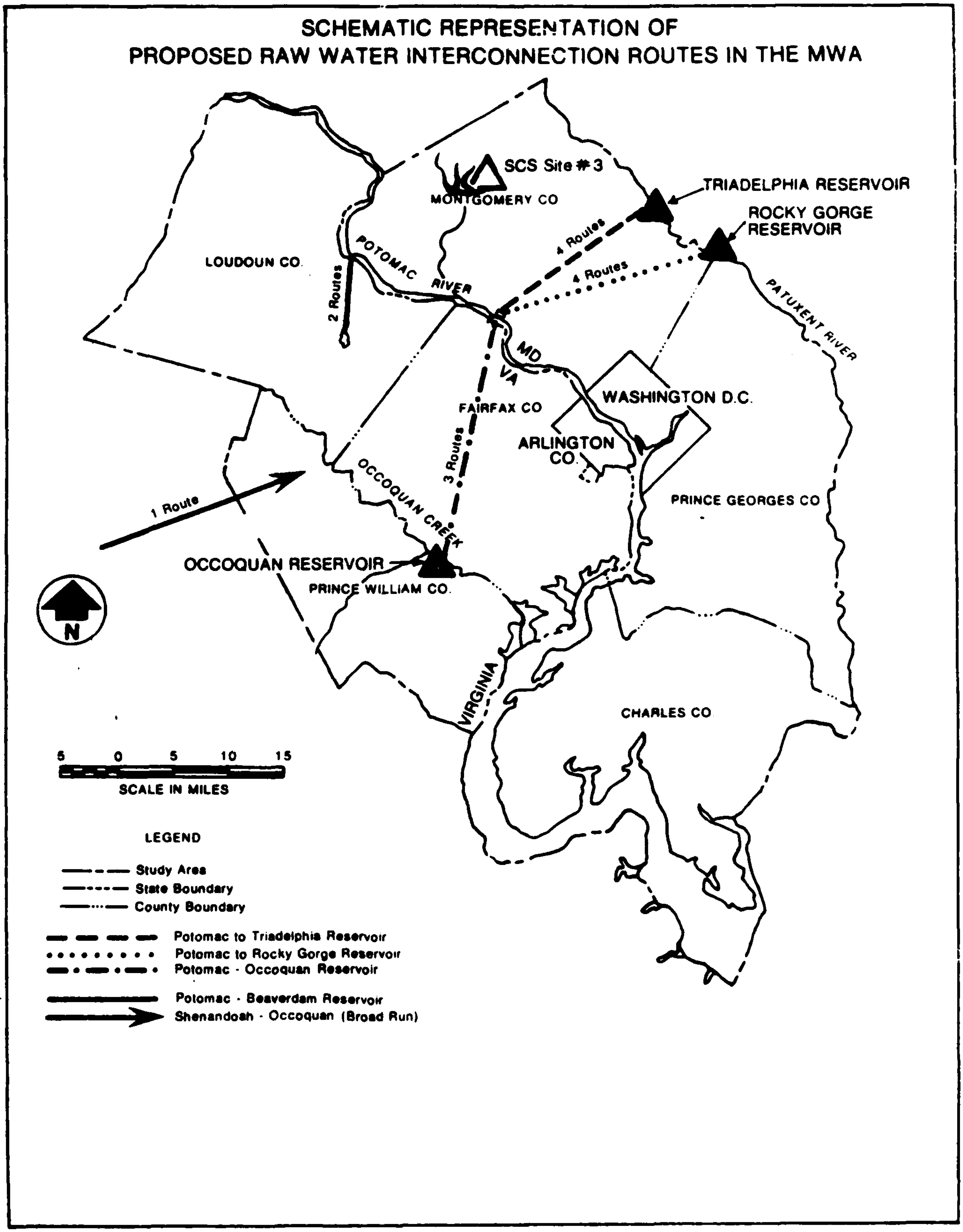
SCHEMATIC REPRESENTATION OF
PROPOSED RAW WATER INTERCONNECTION ROUTES IN THE MWA
SCS Site #3
MONTGOMERY CO
TRIADELPHIA RESERVOIR
ROCKY GORGE RESERVOIR
4 Routes
4 Routes
LOUDOUN CO.
POTOMAC RIVER
2 Routes
PATUXENT RIVER
MD
VA
WASHINGTON D.C.
FAIRFAX CO
ARLINGTON CO.
3 Routes
OCCOQUAN CREEK
1 Route
PRINCE GEORGES CO
OCCOQUAN RESERVOIR
PRINCE WILLIAM CO.
N
VIRGINIA
CHARLES CO
5 0 5 10 15
SCALE IN MILES
LEGEND
Study Area
State Boundary
County Boundary
Potomac to Triadelphia Reservoir
Potomac to Rocky Gorge Reservoir
Potomac - Occoquan Reservoir
Potomac - Beaverdam Reservoir
Shenandoah - Occoquan (Broad Run)

Figure E-3

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MWA-83-P	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY, [redacted] Appendix [redacted] E		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Baltimore District U.S. Army Corps of Engineers, ATTN: NABPL P.O. Box 1715, Baltimore, Maryland 21203		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

water resources planning; water demand; water supply; Potomac River; groundwater; reservoir; raw water interconnection; Low Flow Allocation Agreement; Bloomington Lake; Little Seneca Lake; wastewater reuse; Potomac Estuary Experimental Water Treatment Plant; PRISM/COE; water pricing; water conservation; demand reduction; Cooperative Operations on the Potomac; flowby;

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In response to the Water Resources Development Act of 1974, the Baltimore District of the U.S. Army Corps of Engineers conducted a comprehensive water supply analysis of the Metropolitan Washington Area (MWA). Severe water supply shortages had been forecast for the MWA and the study was undertaken to identify and evaluate alternative methods of alleviating future deficits. Initiated in 1976, the study was conducted in two phases over a 7-year period. The first, or early action phase, examined the most immediate water supply problems and proposed solutions that could be implemented locally. The second or long

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19. KEY WORDS (continued)

water shortage; reregulation; finished water interconnection; Occoquan Reservoir; Patuxent Reservoir; Potomac Estuary; Water Supply Coordination Agreement; Verona Lake

20. ABSTRACT (continued)

range phase included an analysis of the full spectrum of structural and nonstructural water supply alternatives. In addition to such traditional water supply alternatives as upstream reservoir storage, groundwater and conservation, the study also considered such innovative measures as wastewater reuse, raw and finished water interconnections between the major suppliers, the use of the upper Potomac Estuary, reregulation and water pricing. A key tool in the study was the development and use of a basin-specific model that was used to simulate the operation of all the MWA water supply systems and sources under various drought scenarios. As the study progressed, local interests used the technical findings of the Corps' study to make great strides toward a regional solution to their water supply problems. The Corps' study concluded that with the implementation of a series of regional cooperative management agreements, contracts, selected conservation measures, and the construction of one local storage project to be shared by all, severe water supply shortages could effectively be eliminated for the next 50 years. The Final Report of the study is comprised of eleven volumes which provide documentation of both the study process and the results of all the technical analyses conducted as part of the study.

TABLE E-5

PRELIMINARY IMPACT ASSESSMENT FOR POTOMAC RIVER TO TRIADELPHIA RESERVOIR INTERCONNECTIONS

ECOLOGICAL	Route 1	Route 2	Route 3	Route 4
Total Miles of Pipeline	17.2	19.1	21	20.7
Number of Stream Crossing	11	8	11	17
Number of Major 100 Yr. Floodplain Crossings	*	*	*	*
Total Miles Along Major Stream Valleys	1.7	1.6	2.8	3.4
Potential Critical Wildlife Habitat Affected	None	None	None	None
Potential Threatened or Endangered Species Affected	None	None	None	None
Miles Through or Adjacent to Farmland Habitat	9.9	11.5	15.3	16.3
Miles Through or Adjacent to Forest Habitat	8.4	8.1	8.7	7.7
SOCIAL				
Total Miles Along Transportation Routes				
Dual	0	0	0	0
Primary	.8	.7	.6	0
Secondary	.7	3.9	11.6	6.1
Other	0	10.2	7.6	2.3

TABLE E-5 (continued)

	Route 1	Route 2	Route 3	Route 4
Number of Intersections with Transportation Routes				
Dual	1	1	1	1
Primary	6	6	6	6
Secondary	1	5	4	3
Railroad	1	1	1	1
Total Miles Along Existing Utilities				
Water	0	0	0	0
Gas	3.6	2.0	.9	.4
Electric	0	0	0	0
Number of Intersections with Utilities				
Water	0	0	0	0
Gas	8	6	6	3
Electric	2	2	2	2
Number of Known Cultural Resource Areas	6	11	14	13
Potential Cultural Resource Areas	High Potential	High Potential	High Potential	High Potential

TABLE E-5 (continued)

Miles Adjacent to Specific Land Use Type	Route 1	Route 2	Route 3	Route 4
Agricultural	9.9	11.5	15.3	16.5
Woodlands	8.4	8.1	8.7	7.7
Commercial/Industrial	.4	1.7	1.5	1.1
Public	.3	0	.3	0
Recreational	3.6	4.0	3.3	3.7
Residential	2.7	6.2	7.0	5.7
Number of Residents Affected	449	1071	893	763
REAL ESTATE[1] ($1,000,000)				
Total Real Estate Costs				
Land Cost	5.6	9.9	10.6	10.0
Improvements	3.7	7.8	8.5	6.9
Severance	.3	.6	.6	1.2
Relocation	1.6	1.5	1.5	1.9

[1] These costs are approximate costs developed independently from those used for Capital Costs and are based on a preliminary survey by the Real Estate Division, Baltimore District, Corps of Engineers.

TABLE E-6

PRELIMINARY IMPACT ASSESSMENT FOR POTOMAC RIVER TO ROCKY GORGE RESERVOIR INTERCONNECTIONS

ECOLOGICAL	Route 1	Route 2	Route 3	Route 4
Total Miles of Pipeline	22	25	29.5	31.7
Number of Stream Crossings	20	10	12	27
Number of Major 100 Yr. Floodplain Crossings	*	*	*	*
Total Miles along Major Stream Valleys	2.5	4.4	2.0	3.1
Potential Critical Wildlife Habitat Affected	None	None	None	None
Potential Threatened or Endangered Species Affected	None	None	None	None
Miles Through or Adjacent to Farmland Habitat	2.9	7.6	13.8	17.0
Miles Through or Adjacent to Forest Habitat	14.1	9.7	7.1	14.6
SOCIAL				
Total Miles Along Tranportation Routes	4.9	7.3	27.2	9.7
Dual	0	0	0	0
Primary	2.7	0	6.4	.8
Secondary	0	4.6	17	2.5
Other	.2	2.8	3.8	6.4

TABLE E-6 (continued)

Number of Intersections with Transportation Routes	Route 1	Route 2	Route 3	Route 4
Dual	7	4	2	2
Primary	5	6	6	6
Secondary	11	14	13	8
Railroad	1	1	1	1
Total Miles Along Existing Utilities	4.2	9.9	.5	14.1
Water	4.2	1.3	0	1
Gas	0	8.6	.5	0
Electric	0	0	0	13.1
Number of Intersections with Utilities				
Water	1	0	0	0
Gas	0	6	7	4
Electric	3	3	3	4
Number of Known Cultural Resources Areas	3	9	22	9
Potential Cultural Resource Areas	High Potential	High Potential	High Potential	High Potential

TABLE E-6 (continued)

Miles Adjacent to Specific Land Use Type	Route 1	Route 2	Route 3	Route 4
Agricultural	2.9	7.6	13.8	17.0
Woodlands	14.1	9.7	7.1	14.6
Commercial/Industrial	1.9	2.7	2.3	1.4
Public	.6	.3	1.4	0
Recreational	3.7	3.5	2.9	4.3
Residential	11.5	5.9	12.4	5.8
Number of Residences Affected	3300	950	950	1250
REAL ESTATE[1] ($1,000,000)				
Total Real Estate Cost				
Land Cost	14.3	13.1	16.8	11.8
Improvements	10.5	9.8	13.3	8.0
Severance	1.8	1.5	1.7	2.0
Relocation	2.0	1.8	1.8	1.8
Number of Owners Affected	*	*	*	*

[1] These costs are approximate costs developed independently from those used for Capital Costs and are based on a preliminary survey by the Real Estate Division, Baltimore District, Corps of Engineers.

* Information not developed.

TABLE E-7

PRELIMINARY IMPACT ASSESSMENT FOR POTOMAC RIVER TO OCCOQUAN RESERVOIR INTERCONNECTIONS

	Route 1	Route 2	Route 3
ECOLOGICAL			
Total Miles of Pipeline	30.2	30.9	32
Number of Stream Crossings	27	15	42
Number of Major 100 Yr. Floodplain Crossings	*	*	*
Total Miles Along Major Stream Valleys	4.2	1.1	5.0
Potential Critical Wildlife Habitat Affected	None	None	None
Potential Threatened or Endangered Species Affected	None	None	None
Miles Through or Adjacent to Farmland Habitat	8.9	11.5	10.0
Miles Through of Adjacent to Forest Habitat	14.9	13.3	18.3
SOCIAL			
Total Miles Along Transportation Routes	19.7	28.4	8.0
Dual	0	6	0
Primary	0	0	0
Secondary	17	14.9	4.2
Other	2.7	13.5	3.8

TABLE E-7 (continued)

	Route 1	Route 2	Route 3
Number of Intersections with Transportation Routes			
Dual	5	5	5
Primary	0	0	0
Secondary	24	25	15
Railroad	1	1	1
Total Miles Along Existing Utilities	78	.6	24.0
Water	0	0	0
Gas	7.2	0	15.5
Electric	.6	.6	8.5
Number of Intersections with Utilities			
Water	0	0	0
Gas	7	5	6
Electric	4	3	5
Number of Known Cultural Resources Areas	6	2	2
Potential Cultural Resource Areas	High Potential	High Potential	High Potential

TABLE E-7 (continued)

Miles Adjacent to Specific Land Use Type	Route 1	Route 2	Route 3
Agricultural	8.0	11.5	10.0
Woodlands	14.9	13.3	18.3
Commercial/Industrial	0	0	0
Public	.8	.6	.6
Recreational	3.8	4.7	2.3
Residential	9.6	10.5	4.5
Number of Residents Affected	617	656	683
REAL ESTATE[1] ($1,000,000)			
Total Real Estate Costs	8.9	9.5	7.0
Land Cost	6.4	6.9	4.4
Improvements	1.3	1.3	1.3
Severance	1.2	1.3	1.3
Relocation	*	*	*
Number of Owners Affected	*	*	*

[1] These costs are approximate costs developed independently from those used for Capital Costs and are baed on a preliminary survey by the Real Estate Division, Baltimore District, Corps of Engineers.

* Information not developed

cultural, and other values. In addition to the aesthetic and recreation amenities afforded by this stream, there existed a high potential for archaeologic and historic resources in this stream valley in the project area. There would be a minimal impact on residential land, transportation and utilities since the area is mostly in a wooded habitat.

Route #2, which is 5.0 miles in length, minimized the impact on cultural and ecologic features in the area as it paralleled the cleared right-of-way of the VEPCO overhead transmission facilities. The area which is rural in character would have impacts mainly on agricultural, forested and some residential lands. However, the impacts should be minimal. Three small creeks would be crossed by Route #2 including Cattail Branch, Tuscarora Creek and Sycolin Creek, all east-flowing tributaries of Goose Creek, seven intermittent fingertip tributaries would also be affected. The impacts at these crossings would be temporary and would mainly result in an increase in sedimentation in the stream. Two minor roadways, Edwards Ferry Road and Lents Mill Road would be crossed by the pipeline. These roads experienced very little local traffic, so no significant disruptions would be anticipated. The only major roadway affected in the area would be Leesburg Pike (Route #7) which provides a major corridor between Leesburg, Virginia, and the urban core of the MWA. Disruption of commuter vehicles and commercial traffic along this roadway at this locale could be temporarily delayed, however, this should be no longer than a week. The potential for archaeological and historic resources in the project area would be particularly high because of the relatively undisturbed environment in this part of the MWA.

Shenandoah River to Occoquan Creek (Broad Run, Route #1)

The principal ecological impacts to the Shenandoah Pumpover pipeline (22.5 miles in length) generally involved stream crossings, and fish and wildlife habitats. These impacts could be both temporary during construction and/or maintenance, or permanent, resulting from the actual installation of the piping and pumping elements.

The proposed pipeline would intersect a total of 36 streams, 17 of them perennial streams, and 19 of them being seasonal or intermittent. Stream crossings would inflict measureable but temporary adverse impacts on aquatic animals as siltation and other lesser impacts occurred.

Additionally, a certain amount of terrestrial wildlife habitat would have to be altered to provide for the pumping stations and the pipeline rights-of-way. Adjoining areas would be able to serve some of the displaced animals if the areas have not yet reached their carrying capacities for each of the various species affected. In some instances, construction in the pipeline right-of-way would not be detrimental, since home ranges and territories of some animals would be large enough to escape impact.

With regard to endangered species and critical habitat, it was not expected that either would be a determining factor in the construction, operation, or maintenance of a Shenandoah interconnection.

The social impact category included impacts on transportation routes such as roadways, railways and utility service lines since these transportation network segments held significant influence on the lives of persons, the movement of raw materials and finished goods. The proposed right-of-way for the Shenandoah route would intersect eleven different times with existing roadways: one dual highway intersection, four primary road intersections, and six secondary intersections.

According to preliminary plans, the Shenandoah right-of-way would not cross any underground natural gas or petroleum transmission lines. Similarly, no high voltage electrical transmission lines would be crossed or otherwise impacted.

It was expected that social impacts would be temporary and therefore minimal, being restricted mainly to construction, operation, and maintenance periods. Relocations were not foreseen; however, should any be required later, impacts would still be minimal as overall disruption to route directions would not occur. The area proposed for the right-of-way was rural and could be expected to experience only moderate development over the useable life of the project.

There were numerous historical structures that are on record at the Virginia Historic Landmarks Commission and were considered to be of historic interest. Several of these were found adjacent to the interconnection route: Oak Hill and Ashleigh in Fauquier County and Beverly Mill in Prince William County. Overall, ten historic structures of landmarks would experience some degree of impact should the Shenandoah route be implemented. The potential for the presence of buried prehistoric sites was considered to be high along the route. These structures and their impacts are summarized on Table E-8.

Land use impacts took into account the effects the Shenandoah route would have on existing developed and undeveloped land. Since the specific right-of-way that the route would follow was unknown, except that it would follow the alignment of I-66, it was difficult to determine the specific impacts that the pipeline would have on existing land-use patterns. The Virginia Department of Highways and Transportation's EIS for Route I-66 gave some general statements as to the impacts. The I-66 selected route was expected to utilize approximately 1,700 acres of land, of which 424 acres were wooded or in agricultural use, 388 acres were in developed land, and the remaining 938 were devoted to open space. On a county basis, the selected alignment of I-66 would utilize 357 acres in Warren County, 1,015 acres in Fauquier County, and 318 acres in Prince William County; however, the amount of land would be used was small when compared to the total acreage of the three counties.

The few specific acreage figures that were available did, however, indicate some impacts would occur to approximately 211 homes. These existing improvements were not numerous along the pipeline routes, however, and to minimize acquisition costs, and the interface with the residential and/or business activity, the route design would be done in such a way as to by-pass them. The largest concentration of existing improvements were south of I-66 from the Shenandoah River to Marshall, Virginia. Therefore, where the route deviated from the proposed I-66 to the Occoquan system, the improvements tended to be found north of the proposed pipeline route.

Economic Assessment

Using the design and cost methodology described previously, construction and O&M cost estimates were generated for all the alternative raw water interconnections. In order to optimize the design capacities in the preliminary screening process, it was decided to evaluate each alternative route for three capacities: 20 mgd, 50 mgd, and 155 mgd. Additionally, it was decided to evaluate the pipelines as operating in only one direction, and also as reversible interconnections. The summary of these cost estimates, in October 1981 prices, is presented on Table E-9.

TABLE E-8

HISTORIC STRUCTURES AND THEIR IMPACTS
ASSOCIATED WITH THE SHENANDOAH INTERCONNECTION ROUTE

Structure	Impact
Apple Mansion	1,3
Markham4,5	
Rose Bank	1,3,4,5
Smokehouse	1,3,4,5
Cool Spring Church	1,4
Emmanual Church	1,4,5
The Grove	1,5
Thoroughfare Gap	1,3,4,6
Beverly Mill	1,3,4,6
Meadowlands (Ruins)	1,8

Key: 1. Proximity (0-500').

2. Sound-above noise level standards.

3. Precautions during construction.

4. Traffic congestion.

5. Pressure for rezoning.

6. Physical modification of the area.

7. Demolished or relocated.

8. No adverse impacts.

Source: Virginia Department of Highways and Transportation.

Environmental Impact Statement Prepared for I-66 from Gainesville to Front Royal.

TABLE E-9

RAW WATER INTERCONNECTION CONSTRUCTION AND O&M COSTS
OCTOBER 1981 PRICES
(CONSTRUCTION COSTS IN $1,000,000 AND O&M COSTS IN $1,000/DAY

Route Designation	Direction of Flow	20 MGD Pipe Land	20 MGD Pump Sta.	20 MGD Total	20 MGD O&M	50 MGD Pipe Land	50 MGD Pump Sta.	50 MGD Total	50 MGD O&M	155 MGD Pipe Land	155 MGD Pump Sta.	155 MGD Total	155 MGD O&M
Potomac	Pot. to Trid.	14.7	4.1	18.8	4.5	24.1	8.1	32.2	8.6	49.6	19.6	69.2	19.9
Triadelphia	Trid. to Pot.	14.7	3.0	17.7	3.9	24.1	5.4	29.5	7.1	49.6	11.5	61.1	15.2
No. 1	Reversible	14.7	7.1	21.8	—	24.1	13.5	37.6	—	49.6	31.1	80.7	—
Potomac	Pot. to Trid.	16.3	4.4	20.7	5.3	26.8	6.5	33.3	10.1	55.2	20.4	75.6	23.7
Triadelphia	Trid. to Pot.	16.3	3.3	19.6	4.7	26.8	5.8	32.6	8.6	55.2	12.1	67.3	19.0
No. 2	Reversible	16.3	7.7	24.0	—	26.8	12.3	39.1	—	55.2	32.5	87.7	—
Potomac	Pot. to Trid.	17.9	4.6	22.5	5.7	30.0	8.9	38.9	10.7	60.5	21.0	81.5	24.3
Triadelphia	Trid. to Pot.	17.9	3.5	21.4	5.1	30.0	6.2	36.2	9.2	60.5	12.7	73.2	19.6
No. 3	Reversible	17.9	8.1	26.0	—	30.0	15.1	45.1	—	60.5	33.7	94.2	—
Potomac	Pot. to Trid.	17.7	4.6	22.3	5.8	29.1	8.8	37.9	10.9	59.7	20.8	81.3	24.3
Triadelphia	Trid. to Pot.	17.7	3.5	21.2	5.2	29.1	6.1	35.2	9.3	59.7	12.7	73.2	19.6
No. 4	Reversible	17.7	8.1	25.8	—	29.1	14.9	44.0	—	59.7	33.5	94.0	—
Potomac -	Pot. to R.G.	18.9	4.6	23.5	4.0	31.0	8.8	39.8	7.9	63.7	20.4	84.1	19.2
Rocky Gorge	R.G. to Pot.	18.9	4.0	22.9	3.0	31.0	8.5	39.5	5.3	63.7	15.7	79.4	11.1
No. 1	Reversible	18.9	8.6	27.5	—	31.0	17.3	48.3	—	63.7	36.1	99.8	—
Potomac -	Pot. to R.G.	21.4	5.4	26.8	4.2	35.1	10.4	45.5	8.3	72.2	24.4	96.6	19.8
Rocky Gorge	R.G. to Pot.	21.4	4.8	26.2	3.1	35.1	8.8	43.9	5.7	72.2	19.6	91.8	11.7
No. 2	Reversible	21.4	10.2	31.6	—	35.1	19.2	54.3	—	72.2	44.0	116.2	—
Potomac -	Pot. to R.G.	25.2	5.9	31.1	4.5	41.5	11.1	52.6	8.6	85.1	25.0	97.2	20.4
Rocky Gorge	R.G. to Pot.	25.2	5.3	30.5	3.4	41.5	9.5	51.0	6.0	85.1	20.2	92.4	12.3
No. 3	Reversible	25.2	11.2	36.4	—	41.5	20.6	62.1	—	85.1	45.2	117.4	—
Potomac -	Pot. to R.G.	26.3	6.0	32.3	4.4	43.2	11.1	54.3	8.6	88.9	25.0	97.2	20.3
Rocky Gorge	R.G. to Pot.	26.3	5.4	31.7	3.4	43.2	9.6	52.8	6.0	88.9	20.0	92.2	12.2
No. 4	Reversible	26.3	11.4	37.7	—	43.2	20.7	63.9	—	88.9	45.0	117.2	—

TABLE E-9 (continued)

Route Designation	Direction of Flow	20 MGD Pipe Land	20 MGD Pump Sta.	20 MGD Total	20 MGD O&M	50 MGD Pipe Land	50 MGD Pump	50 MGD Total	50 MGD O&M	155 MGD Pipe Land	155 MGD Pump	155 MGD Total	155 MGD O&M
Potomac - Occoquan No. 1	Pot. to Occ.	25.9	5.6	31.5	5.4	42.4	10.1	52.5	9.8	87.3	21.8	109.1	21.2
	Occ. to Pot.	25.9	5.9	31.8	5.7	42.4	10.9	53.3	10.6	87.3	24.4	111.7	23.7
	Reversible	25.9	11.5	37.4	-	42.4	21.0	63.4	--	87.3	46.2	133.5	--
Potomac - Occoquan No. 2	Pot. to Occ.	26.5	5.7	32.2	5.5	43.4	10.4	53.8	10.1	89.3	22.4	109.7	21.9
	Occ. to Pot.	26.5	6.0	32.5	5.9	43.4	11.2	54.6	10.9	89.3	25.0	112.3	24.4
	Reversible	26.5	11.7	38.2	--	43.4	21.6	65.0	--	89.3	47.4	134.7	--
Potomac Occoquan No. 3	Pot. to Occ.	27.4	5.7	33.1	5.6	44.9	10.3	53.7	10.2	92.5	21.8	114.3	21.4
	Occ. to Pot.	27.4	6.1	33.5	5.9	44.9	11.1	54.5	10.8	92.5	24.4	116.9	23.9
	Reversible	27.4	11.8	39.2	--	44.9	21.4	64.8	--	92.5	46.2	138.7	--
Potomac - Goose Creek No. 1	Pot. to G.C.	4.4	1.4	5.8	1.3	7.2	2.7	9.9	2.6	14.9	6.7	21.6	6.6
Potomac - Goose Creek No. 2	Pot. to G.C.	4.4	1.0	5.4	1.1	6.7	2.0	8.7	1.8	13.7	4.6	18.3	3.7
Shenandoah - Occoquan Cr. (Broad Run)	Shen. to Occ.	19.4	6.2	25.6	6.1	31.7	12.8	44.5	12.5	65.3	32.5	97.8	31.4

Optimization Analysis

The optimization analysis determined which raw water interconnections would provide, in the absence of other components being studied, the "best" solutions to the water shortage problems. The qualifying criteria used to identify preferred interconnections was that they prove feasible from both a technical and economic standpoint.

A linear program was employed to find the combination of interconnections which, when tested against the critical supply period (July through December 1930) could meet the average monthly demands at minimum capital cost. A similar analysis was conducted for 7-day duration drought. Output from this analysis indicated which interconnections were needed and what size of pipe would be required to transfer water to meet the projected needs if no other water supply augmentation other than Bloomington Lake were implemented in the near future. Much of this work was accomplished by the consulting firm of GKY & Associates, Inc. and is documented in a report on file in the Baltimore District.

Several important findings were produced from the raw water interconnection optimization analysis. (1) raw water interconnections were feasible and could provide a mechanism to move water to service areas which experience shortages. With raw water interconnections in place and properly sized, sufficient water could be transferred and/or stored to meet projected demands; (2) pipelines to either the Patuxent system or the Occoquan system were feasible; (3) either a Potomac to Occoquan, Potomac to Cub Run, or Shenandoah to Broad Run pipe line would be feasible for interconnecting the Occoquan Reservoir and; (4) increasing the volume of flowby directly affects the size and timing of required raw water interconnections.

Also as a result of the optimization analysis it was determined that the Potomac River - Rocky Gorge interconnections had advantages over the Potomac River - Triadelphia interconnections for the following reasons:

1. With proper operation, a Rocky Gorge interconnection system could make use of the available storage in both the Rocky Gorge and Triadelphia Reservoirs which would reduce the risk of shortage in the event of a drought. An interconnection to the Triadelphia Reservoir could only utilize the storage from the one reservoir.

2. The proximity of treatment facilities to either end of the Rocky Gorge pipeline would provide for a more effective and rapid response time for raw water delivery from its source to treatment. Thus water could be more readily made available for distribution to the users. Potomac water could also be transferred directly to the Patuxent treatment plant without the need for putting the transferred water into the reservoir. When operating in this mode, withdrawals from the reservoir could be decreased (this was a particularly important point as discussed later).

3. The Bi-County Water Supply Task Force, comprised of representatives from the Washington Suburban Sanitary Commission (WSSC) and Prince Georges and Montgomery Counties, Maryland had contracted for an alignment study of the proposed cross county pipeline between the Potomac River and Rocky Gorge Reservoir and the Potomac and Patuxent Treatment facilities. This action was based on results of a 2-year study which found the reversible pipeline to be a favorable project.

On the basis of these points, the Potomac-Rocky Gorge interconnection was retained for further investigation and the Potomac-Triadelphia interconnection was not studied further.

ROUTE SELECTION

Using a process of data tabulation, ranking, and evaluation, each of the remaining configuration groupings was analyzed according to the degree of preferability within impact categories.

The more significant impact categories used in performing this assessment were capital costs, real estate costs, miles along stream valleys, land use effects, transportation, cultural effects and ease of implementation. The importance of these criteria were discussed in a previous section. Using these criteria as indicators in terms of measuring relative impacts each route was ranked according to degree of impact anticipated. Table E-10 expresses the preferablity of routes among the major impact categories. Since only one route alignment was considered for the Shenandoah-Occoquan interconnection, it is not included in this table.

The results of this ranking process were evaluated in conjunction with the technical results from the optimization analysis. As previously indicated, the four Potomac - Triadelphia interconnection routes were eliminated based on the results of the optimization analysis. The Potomac River - Rocky Gorge Routes #3 and #4, the Potomac River - Occoquan Route #2, and the Potomac River - Goose Creek Route #2 were eliminated since they consistently ranked last or next to last according to the degree of preferablity for the major impact categories in Table E-10.

In an effort to reduce the route alignments to one per group, the screening process was taken one step further with the elimination of the Potomac River - Occoquan Route #1 and the Potomac River - Rocky Gorge Route #2. Since the Potomac-Occoquan #3 would avoid the densely populated areas of Fairfax County and could use or parallel utility rights-of-way for large portions of the route (and thus minimize environmental and social impacts) it would be preferred over the Potomac-Occoquan #1. Data generated for the Potomac River-Rocky Gorge Routes #1 and #2 as a result of the impact assessment indicated that there was no large difference in the overall impacts for these pipelines. Although institutional problems might arise in the future should the Potomac-Rocky Gorge Route #1 be used jointly with the proposed Intercounty Connector roadway, there had been no firm commitment at the time of analysis as to the final selection of an Intercounty Connector alignment (a long-term study of alternative roadway alignments was being planned by the Maryland State Highway Department). Because much of the land available for the potential roadway was owned by Montgomery County and was undeveloped, it provided a low socially disruptive pipeline corridor. Coupled with its relative low cost in comparison with Potomac-Rocky Gorge Route #2, Rocky Gorge #1 was selected as the Patuxent interconnection route for detailed study. As a result of this preliminary evaluation and screening process, Table E-11 lists those raw water interconnection route alignments that were recommended for further analysis.

FINAL SCREENING OF ROUTES

Selection of the final raw water interconnection projects for design and detailed cost was accomplished through realignment investigation, revised environmental impact analysis, and engineering optimization.

TABLE E-10

TRADE-OFF ANALYSIS FOR RAW WATER INTERCONNECTIONS - (WITHIN GROUPINGS)

	Criteria/ Ranking	ROUTES PREFERRED Most Preferred	Next Preferred	Next Preferred	Least Preferred
Potomac	Capital Costs	PR-1	PR-2	PR-3	PR-4
to	Real Estate Costs	PR-2	PR-4	PR-3	PR-1
Rocky Gorge	Effects on:				
Reservoir	Environmental Quality	PR-3	PR-1,2	PR-4	
	Land Use	PR-2	PR-3	PR-4	PR-1
	Transportation	PR-4	PR-2	PR-3	PR-1
	Cultural Resources	PR-1	PR-2	PR-4	PR-3
	Ease of Implementation	PR-1	PR-2	PR-3,4	
Potomac	Capital Costs	PO-1	PO-2		PO-3
to	Real Estate Costs	PO-3	PO-1		PO-2
Occoquan	Effects on:				
	Environmental Quality	PO-2	PO-1		PO-3
	Land Use	PO-1	PO-3		PO-2
	Transportation	PO-3	PO-1		PO-2
	Cultural Resources	PO-2,3	PO-1		
	Ease of Implementation	PO-2	PO-1	PO-3	
Potomac	Capital Costs	PB-1			PB-2
to	Real Estate Costs	PB-1			PB-2
Beaverdam	Effects on:				
Reservoir	Environmental Quality	PB-2			PB-1
	Land Use	PB-2			PB-1
	Transportation	PB-2			PB-1
	Cultural Resources	PB-2			PB-1
	Ease of Implementation	PB-2			PB-1

TABLE E-11

RAW WATER INTERCONNECTION ROUTES RECOMMENDED FOR FURTHER ANALYSIS

ROUTE DESIGNATION	POINT SOURCE
Potomac River - Rocky Gorge Reservoir Route #1	Potomac River-Patuxent River
Potomac River - Occoquan Reservoir Route #3	Potomac River-Occoquan Creek
Shenandoah River - Occoquan River (Broad Run) Route #1	Shenandoah River-Occoquan Creek
Potomac River - Goose Creek Reservoir Route #2	Potomac River-Goose Creek

During the course of this work effort, the following events occurred which affected the routes investigated: (1) the Virginia State Water Control Board requested the Corps to investigate an interconnection between the Potomac River and Cub Run; and (2) the proposed interconnection between the Potomac River and Goose Creek Reservoir was extended further upstream to terminate at Beaverdam Reservoir. The Beaverdam Reservoir was chosen based on the idea that by extending this line maximum use could be made of the storage capacity at Beaverdam, which is considerably larger than Goose Creek Reservoir (2.5 billion gallons to 0.5 bg). Additionally, this interconnection would allow for requested releases from Beaverdam Reservoir to Goose Creek. The Potomac River - Cub Run and the Potomac River - Beaverdam Reservoir Interconnections were included in the additional investigation. Table E-12 presents all the route that were considered in the final analysis.

REALIGNMENT INVESTIGATIONS

The route realignment investigation consisted of identifying specific segments along a given route where potential impact could be significantly reduced or eliminated. Table E-13 lists in summary form the various changes affecting each route. The following section provides a detailed description of each route alignment.

Potomac River - Rocky Gorge Reservoir Route #1

The route begins at the site of the Washington Suburban Sanitary Commission's Potomac intake structure and follows an existing Transcontinental Gas pipeline clearing in a northerly direction, by-passing the Potomac Water Treatment Plant, until it intersects an existing Pepco Overhead Transmission Line (OTL) clearing. At this point, the route follows the alignment of the proposed intercounty connector as follows: bearing east following Montrose Road across Washington National Pike (I-270) and Georgetown Road to Rockville Pike (Route #355). At the intersection of Montrose and Rockville Pike, the route bears northeast crossing the Baltimore and Ohio Railroad tracks, Viers Mill Road (Route #586), Connecticut Avenue (Route #185), and Georgia Avenue to Layhill Road. At Layhill Road, the route bears east traveling across New Hampshire Avenue (Route #650), Good Hope Road, Old Columbia Road (Route #196), and Columbia Pike

TABLE E-12

REVISED RAW WATER INTERCONNECTION ROUTES
RECOMMENDED FOR FURTHER ANALYSIS

Route Designation	Point Source
Potomac River -Rocky Gorge Reservoir Route #1	Potomac River - Patuxent River
Potomac River - Occoquan Reservoir Route #3	Potomac River - Occoquan Creek
Shenandoah River - Occoquan Creek (Broad Run) Route #1	Shenandoah River - Occoquan Creek
Potomac River - Beaverdam Reservoir Route #2	Potomac River - Beaverdam Creek
Potomac River - Cub Run Route #1	Potomac River - Cub Run

(Route #29), to the point where Briggs Changy Road crosses a WSSC water pipeline. At this point, the route follows the WSSC water pipeline clearing in a northerly direction crossing Greencastle and Gunpowder Roads to the Patuxent Water Treatment Plant. The route then leaves the plant and follows an existing Pepco OTL clearing across Spencerville Road directly to the Rocky Gorge Reservoir. The overall length of this route is approximately 23 miles.

Potomac River - Occoquan Reservoir Route #3

The Potomac River to Occoquan Reservoir is approximately 29 miles long. The route begins at the site of the Fairfax County Water Authority's Potomac River intake structure on Lowes Island and parallels the Virginia shoreline in a southeast direction to the northern extension of Seneca Road. At this point, the route follows Seneca Road in a southerly direction to the intersection of Georgetown Road (Route #193) and an existing Colonial Gas pipeline. The route then follows the pipeline clearing across Leesburg Pike (Route #7), a Columbia gas line clearing (Route #602), Baron Cameron Avenue (Route #606), an abandoned Washington and Old Dominion railroad grade, Sunset Hills Road (Route 675), Dulles Airport Road, Fox Hill Road, and Route #50 to Stringfellow Road (Route #645). The route then continues in a southerly direction following Stringfellow Road across I-66 and Lee Highway. On the south side of Lee Highway, Stringfellow Road (Route #245) changes to Clifton Road (Route #645). The route continues down Clifton Road to Cloverleaf Farm Estates. At this point, the route leaves Route #645 and still traveling south, traverses a small portion of open country crossing Compton Road until it intersects with a VEPCO OTL clearing. The route follows this OTL clearing in a southeasterly direction crossing Henderson Road (Route 643), a north-south VEPCO OTL and Hampton Road until its intersection with a second north-south VEPCO OTL. At this point the line bends south paralleling the OTL directly to the Occoquan Reservoir. The FCWA WTP by-pass begins at the intersection of the Colonial and Columbia Gas Lines just south of Leesburg Pike. The line then travels approximately 5,200 feet to the

TABLE E-13

RAW WATER INTERCONNECTIONS REALIGNMENT CHANGES

Raw Water Interconnection Route	Segments of Routes Affected	Problems Encountered	Realigned Portions	Benefit
Potomac/Rocky Gorge #1	a. From Potomac WTP, west crosscountry to PEPCO overhead transmission lines in the vicinity of Beverly Farms.	a. Crosses wooded land farmland and suburban residential communities.	a. Utilize in part right-of-way of Transcontinental Gas Lines northeast from Potomac WTP to PEPCO overhead transmission facilities. Follow southeast to resume with original configurations near Beverly Farms.	a. Avoids social and environmental disruption over crosscounty portion.
	b. From Patuxent WTP, northeast crosscountry to Rocky Gorge Reservoir.	b. Crosses residential development (Rocky Gorge Estates)	b. Continue from Patuxent WTP north along rights-of-way of PEPCO overhead transmission lines Rocky Gorge Reservoir.	b. Avoids social disruption to residential housing development. Decreases costs for land.
Potomac/Occoquan #3 area	a. Portion of route 603 east of route 602 and Colonial Gas Line right-of-way back to route 602.	a. Narrow wooded sinuous, and steep portion on route 603.	a. From Lowes Island intake area south to Seneca Road (602) to Georgetown Pike (193) and Colonial Gas Line.	a. Avoid construction and environmental problems of Route 603. Shorten route and reduce.
	b. Portion of route east of Stringfellow Road in the vicinity of I-66 and Willow Springs.	b. Existing alignment segment inaccessible with no potential overpass for I-66 at Braddock Road on Rt. 245 (Clifton Road).	b. Follow Stringfellow Road south, crossing I-66 Rt 29/211 and resume original configuration.	b. Potential use of 245 overpass over I-66.
	c. Clifton Road approximately .5 miles south of Cloverleaf Estate along Clifton Road, west to VEPCO transmission lines.	c. Narrow, undulating and sinuous portion.	c. Continue south in straight crosscountry pass 1/2 mile south of Cloverleaf Estate to overhead VEPCO transmission facilities. Continue east on route.	c. More direct and decrease overall length. Reduce impacts in wooded areas and eliminate traffic problems near Clifton, Virginia.

TABLE E-13 (continued)

RAW WATER INTERCONNECTIONS REALIGNMENT CHANGES

Raw Water Interconnection Route	Segments of Routes Affected	Problems Encountered	Realigned Portions	Benefit
Shenandoah/ Occoquan	a. Intake Location on Shenandoah River at PEPCO power plant Front Royal, Virginia.	a. Steep valley sidewalls, little room for pumping station.	a. Relocate intake 1 mile upstream.	a. Avoid pumping problems and location of pumping station.
	b. Discharge location of Broad Run near Old Tavern, Virginia.	b. Inadequate capacity of stream channel at discharge location and downstream along I-66 for approximately 5 miles.	b. Relocate discharge point to Broad Run at Thoroughfare Gap, Virginia. Requires extension of route.	b. Discharge water in channel at location with adequate capacity. Reduce adverse effect on channel and fish and wildlife.

treatment plant. The by-pass line for the Lorton WTP begins at the intersection of a north-south and east-west VEPCO OTC just upstream, on the northside of the Occoquan Dam. The line parallels the OTL for approximately 7,000 feet to the treatment plant.

Potomac River - Beaverdam Reservoir Route #2

The Potomac River to Beaverdam Creek (tributary to Goose Creek) is approximately 8 miles long. The route begins at the VEPCO OTL clearing approximately one-half mile downstream from Harrison Island. It follows the OTL clearing in a southwesterly direction until it intersects Route #643 then bends southeast and follows Route #643 until it intersects with Route #659. At this intersection, the route bends south and follows Route #659 for approximately one mile then bends directly west and travels across open country to Beaverdam Creek.

The by-pass line to the Fairfax City Water Treatment Plant begins at the intersection of Routes #659 and #643. The line travels north on Route #659 for approximately 4,000 feet to the treatment plant.

Shenandoah River - Occoquan Creek (Broad Run) Route #1

The Shenandoah River to Occoquan Creek (Broad Run) route is approximately 27 miles long. The route begins on the south shore of the Shenandoah River approximately one mile upstream of the Potomac Edison Power Company's Warren Hydrostation and dam located downstream of Front Royal, Virginia. From this point, the route travels directly south until it intersects I-66. The route then follows I-66 which merges, with Routes #17 and #55, to Thoroughfare Gap and terminates at Broad Run.

Potomac River - Cub Run Route #1

The Potomac River to Cub Run is approximately 18.2 miles long. The route begins at the site of the Fairfax County Water Authority's Potomac River intake structure on Lowes Island and parallels the Virginia shoreline in a southeast direction to the northern extension of Seneca Road. At this point, the route follows Seneca Road in a southerly direction to the intersection of Georgetown Road (Route 193) and an existing Colonial Gas pipeline. The route then follows the pipeline clearing across Leesburg Pike (Route 7), Route 602, Baron Cameron Avenue (Route 606), an abandoned Washington and Old Dominion railroad garde, Sunset Hills Road (Route 675), Dulles Airport Road, Fox Hill Road, and Route 50. The route then intersects the Transcontinental pipeline and follows it in a southerwesterly direction across County Routes 657, 28, 620, and 662 and terminating at Cub Run opposite the sewage disposal plant.

ENVIRONMENTAL ANALYSIS

For the selection of the final raw water interconnections a more detailed assessment of environmental and social impacts was undertaken. The following section describes the environmental, social, and recreational impacts for the various route alignments.

Environmental Impacts

Potomac River - Rocky Gorge Reservoir Route #1

In being aligned in a more southern position with regard to the most populative area of Montgomery County, Route 1 traverses areas improved with residential construciton, some commercial development, and a limited number of farms. Construction of a pipeline would cause considerable adverse impacts due to land or easement requisitions, relocations, construction, and operation and maintenance construction activities in themselves would present the greatest adverse impacts to area residents. Light, noise, dust, vibrations, traffic congestion, and impaired aesthetics would occur should construction be accomplished. Some mitigation measures would possibly alleviate some impacts during construction; however, overall quality of the social and the physical environments would suffer degradation.

This route is located in areas of high density development and medium wildlife values; however, the areas do not possess unique fish and wildlife habitat values. Impacts associated with this right-of-way in terms of stream crossings and floodplains crossed can be mitigated if the proper precautions such as erosion and sedimentation controls are followed. This would greatly alleviate adverse impacts on fish and wildlife. Route 1 would require numerous stream and floodplain crossings thereby causing temporary impacts that include stream water quality degradation resulting from increased turbidity, sedimentation, and displacement of both aquatic and terrestrial organisms in the immediate project area. In no instance, however, does the route traverse or otherwise affect any critical wildlife habitat.

Potomac River - Occoquan Route #3

In the case of Route 3, the alignment follows existing utility easements for almost all of its existing length. Aligned in a north to south direction, the pipeline passes next to or under the Colonial Gas Company's underground transmission line and/or the Virginia Electric and Power Company's high voltage overhead electric powerline.

Scattered residential dwelling units exist along the proposed alignment; however, no concentrations of heavy commercial, industrial, or public land-uses are present. Route 3 would require 42 stream crossings causing temporary impacts that included stream water quality degradation, and displacement of aquatic and terrestrial organisms in the immediate project area. However, given the fact that utility easements are closely followed, it is not anticipated that Route 3 will cause any permanent adverse impacts on Fairfax County's social or economic environments.

Potomac River - Beaverdam Reservoir Route #2

Since the Potomac River to Beaverdam Reservoir interconnection pipeline is rather short and parallels the Virginia Electric and Power Company's high voltage overhead electric powerline until it branches eastward to cross Goose Neck at Murray's Ford Bridge, impacts will be restricted mainly to short-term adverse effects of construction and periodic maintenance. The remainder of the interconnection route parallels the right-of-way of State Route 659 and crosses a small hilly wooded area in the vicinity of the Beaverdam Creek Dam. Impacts to this section would be of greater significance;

however, due to the small area in question, it is not felt that any adverse impacts would be irreparable. Tree cover would be lost, topsoil would be disturbed, and overall aesthetics would be affected in this instance. In terms of overall developed land-use, 14 houses or farms would be impacted. This quantity is slight in comparison to other raw water pipelines.

This route would produce only minimal impacts as it follows an existing overhead transmission line right-of-way for a large portion of its route. The stream crossing impacts will be similar to those experienced in other raw water interconnections, but should be localized to alteration and loss of riparian vegetation and benthic population in the stream, if proper construction measures are used.

Shenandoah River - Occoquan Creek (Broad Run) Route #1

This route is also known as the Shenandoah Pumpover since it will deliver water via a pressurized pipeline over the Blue Ridge. The impacts likely to occur from this raw water interconnection would be felt mainly on the transportation system in Warren and Fauquier County. The proposed right-of-way for the Shenandoah route would intersect approximately 11 times with existing roadways: one dual highway, four primary roads, and six secondary roads. However, according to preliminary information, this route would not cross any underground natural gas or petroleum transmission lines. Similarly, no high voltage electrical transmission lines would be crossed or otherwise impacted.

It is expected that social impacts will be temporary and therefore minimal, being restricted mainly to construction, operation, and maintenance periods. Relocations are not foreseen; however, should any be required later, impacts will be minimal due to the open nature of the pipeline corridor. Moreover, the area proposed for the right-of-way is rural and can be expected to experience only moderate development over the useable life of the project.

The pipeline route planned to be utilized should provide an environmentally acceptable route alignment. The habitat affected by pipeline construction is considered to be of good quality and will be affected only temporarily. There will be approximately thirty-six streams crossed; however, these crossings will be in areas recently impacted by highway construction. With proper erosion and sediment control, impacts should be minimized.

Potomac River - Cub Run Route #1

Since the Cub Run interconnection pipeline utilized the Potomac-Occoquan alignment south to the point where the Transcontinental Gas intersects, land-use impacts are the same as the Potomac to the Occoquan up to this point. South from this point, the Cub Run interconnection follows the Transcontinental Gas pipeline to a discharge point on Cub Run. The land-use impacts are minimal with no major development areas affected except for some recent residential development in the vicinity of U.S. Route 50 and Lees Corner Road.

The fact that this route will effectively utilize other interconnection and utility easement alleviates any unique adverse impacts to fish and wildlife habitat. Any construction, however, will generate temporary impacts that can be controlled through proper construction techniques.

Any stream crossings impacts will be similar to those experienced in other areas, but should be localized to alteration and loss and riparian vegetation and benthic population in the stream. Overall and in any case, the impacts on fish and wildlife or its habitat are viewed as insignificant or minimal.

Recreation Impacts

In regards to recreational impacts for each of the five raw water interconnected routes, Tables E-14 to E-18 presents the park or recreational area affected, any facilities that the park has, pipeline and right-of-ways relative to this area, and an easement of the expected impacts. To aid the reader in interpreting these tables, definitions of these categories follows:

Name: The name of the various parks impacted

Type of Park: The various types of parks contained in this study area are:

Regional Park - A regional park provides the setting for activities that are primarily related to the enjoyment of nature and the natural scenery. These activities include: picnic areas, water-oriented activities, natural trails and camp grounds. The regional park usually draws people from all areas of a region.

Local Park - A local community park is usually adjoined to a public school. They draw people mostly from the immediate neighborhood and offer a wide variety of recreational activities such as tennis courts, playgrounds, and athletic fields.

Conservation Area - A conservation area is parkland that protects areas that have a high ecological value (marshland, floodplains) or high social value (historical areas) from unsuitable development.

Facilities: the current recreational facilities available to the park.

Location of right-of-way: A description of the location of the right-of-way relative to the park.

Impacts: the various impacts associated with the parks are as follows:

Aesthetic Impact - The parks value as a wildlife habitat and corridor and as a visual resource may be disrupted by removal of forest cover and/or increases in construction noises. Impact would occur in the conservation areas and regional parks that try to maintain the natural environment. Impacts would occur mostly during construction but there also exists the possibility of some long term effects. By making use of existing rights-of-way, if possible, and selective cutting, these impacts can be kept to a minimum.

Noise and Visual Impact - This impact would apply to all areas where recreational activities could possibly be impacted by the construction activities. The use of the recreational facilities might be curtailed by the high noise levels or visual disruptions. This impact would be confined to the construction period and could be reduced if the construction activities were scheduled for periods of non-use.

TABLE E-14

RECREATIONAL IMPACTS POTOMAC RIVER TO ROCKY GORGE - ROUTE 1

Name	Type of Park	Facilities	Location of Right-of-Way Relative to Park	Impacts	Remarks
Watts Branch	Conservation Area	N/A	Right-of-way transverse 2,000 ft. of parkland	1. Aesthetic Impact	
Rock Creek	Conservation Area	N/A	Right-of-way transverse 1,500 ft. of parkland	1. Aesthetic Impact	
Bel-Pre	Local Community	Picnic Playground	Park lies on northern boundary of right-of-way	1. Noise and visual impacts	
Layhill	Local Community	Playground Ballfields	Park lies on northern boundary of right-of-way	1. Noise and visual impacts	
Northwest	Conservation Area	N/A	Right-of-way transverse approx. 2,000 ft. of parkland	1. Aesthetic Impact	
Fairland	Regional	Undeveloped	Right-of-way transverse approx. 2,000 ft. of parkland	1. Aesthetic Impact 2. Physical impacts 3. Noise and visual in the park	The extent of the impacts on recreation facilities depend upon the level of development.

TABLE E-15

RECREATIONAL IMPACTS POTOMAC RIVER TO OCCOQUAN RESERVOIR ROUTE 3

Name	Type of Park	Facilities	Location of Right-of-Way Relative to Park	Impacts	Remarks
Northern Virginia Regional Park	Regional	Undeveloped	Right-of-way transverses approx. 3,500 ft. of parkland	1. Aesthetic Impact 2. Physical Impacts 3. Noise and Visual Impacts	The extent of recreational impacts will be dependent upon the level of recreation development. NVRPA has acquired approx. 700 acres of undeveloped lands in the uppermost section of Fairfax Ct. The acquisition of these lands and future recreational developments will serve to aid in the protection of these ecologically sensitive and natural resource areas and to help meet the growing recreational demands of the MWA.
Greenbrier	Local Community Park	Baseball, Basketball Football Tennis, Trails	Right-of-way follows Rt 645 along western boundary of park	1. Noise and Visual Impacts 2. Access to Park	
Arrowhead Community	Local Park	Undeveloped	Right-of-way follows Rt. 645 along eastern boundary of park	1. Noise and Visual 2. Access to Park	The extent of recreational impacts will be dependent upon the level of recreational development. Current 5-year development plan includes ballfields, playgrounds, trails and tennis courts.
Braddock	Local Community Park	Baseball Football	Right-of-way follows Rt. 645 along eastern boundary of park	1. Noise and Visual 2. Access to Park	
Twin Lakes	Golf Course	Golf Course	Right-of-way follows Rt. 645 along eastern boundary of park	1. Noise and Visual 2. Access to Park	

TABLE E-16

RECREATIONAL IMPACTS POTOMAC RIVER TO BEAVERDAM - ROUTE 1

Name	Type of Park	Facilities	Location of Right-of-Way Relative to Park	Impacts	Remarks
Goose Creek	Regional	Undeveloped	Right-of-way transverse approx. 8,000 ft. of parkland	1. Aesthetic 2. Physical 3. Noise and Visual Impacts	A 365-acre site is being acquired by the NVRPA at the confluence of Goose Creek and the Potomac River. The acquisition of this environmentally sensitive area will preserve over 2.2 miles of Potomac shoreline and 3/4 mile of Goose Creek frontage. Recreational facilities will provide much needed access to this section of the Potomac. The extent of recreational impacts would be dependent upon the level of development.

TABLE E-17

RECREATIONAL IMPACTS SHENANDOAH RIVER TO OCCOQUAN CREEK - ROUTE 1

Name	Type of Park	Facilities	Location of Right-of-Way Relative to Park	Impacts
Appalachian Trail	Trail	Hiking	Right-of-way crosses trail near town of Lineden	Some Noise and Visual Impacts but should not effect use of trail
Bull Run Mountain	State Park	Proposal	Right-of-way would follow I-66 through the Park area	Some Noise and Visual Impacts

TABLE E-18

RECREATIONAL IMPACTS POTOMAC RIVER TO CUB RUN - ROUTE 1

Name	Type of Park	Facilities	Location of Right-of-Way Relative to Park	Impacts	Remarks
Northern Virginia Regional Park	Regional	Undeveloped	Right-of-Way transverses approx. 3,500 ft. of parkland	1. Aesthetic Impact 2. Physical Impact 3. Noise and Visual Impacts	See Potomac to Occoquan Route 3
Frog Branch	Conservation Area	Picnic Areas	Right-of-way transverse approx. 500 ft. of parkland of parkland	1. Aesthetic Impact 2. Noise and Visual Impacts	
E. C. Lawrence	Conservation Area - Local Park	Fishing, Nature Trails, Historical Area	Right-of-way transverse approx. 3,000 ft. of parkland	1. Aesthetic Impact 2. Noise and Visual Impact	

Physical Impact - The impact applies to areas that would possibly have the physical loss of recreational facilities during construction activities. By providing temporary recreation facilities nearby, this impact could be minimized.

Access to Park - This impact applied to parks that may not have adequate access, due to road obstructions, during construction activities. By providing alternate routes this impact could be minimized.

ENGINEERING ANALYSIS

In order to evaluate the engineering feasibility of the remaining raw water interconnections the optimization model was again used. Basically, the model's purpose was to verify through the use of optimization techniques whether or not the projects identified as environmentally feasible could, under a given set of conditions, optimize the transfer of water between two interconnected sources (e.g. Potomac River and Rocky Gorge Reservoir) in such a manner as to satisfy the area's demands. The following section describes the model input parameters defined for this study, period of analysis, and the raw water interconnection projects analyzed.

Input Parameters and Analysis Period

The raw water optimization linear program required input for reservoir inflows and usable storage, supply flows, demands and unit costs of installed pipelines. The supply input data used consisted of inflows for the Occoquan and Patuxent Rivers, releases from Bloomington, and stream flow data obtained for the Potomac and Shenandoah Rivers and Goose Creek. The demand data used in this analysis was for the Washington Aqueduct Division (WAD), Washington Suburban Sanitary Commission (WSSC), Fairfax County Water Authority (FCWA), Fairfax City and Rockville water service areas. These data were aggregated and applied to the various major water supply sources: Patuxent River, Goose Creek, Occoquan Creek, and Potomac River. In aggregating the data, the WSSC was divided between the Patuxent Reservoir and the Potomac River based on the Patuxent Reservoir treatment plant capacity. Similarly, for the FCWA water service areas, the demand data were divided between the Occoquan Reservoir and the Potomac River based on its reservoir treatment plant capacity. For the WAD and Rockville water service areas, the demands were applied to their only supply source, the Potomac River. Finally, the Fairfax City demands were assumed to be met by its only supply source, Goose Creek. The remaining input data required for operation of the optimization model was the pipeline costs previously generated. The general time frame chosen for the analysis period was the 1930-1932 drought. This particular period was selected since it represented the worst 30-day duration recorded in the MWA. The raw water interconnection projects chosen for the engineering analyses were:

Potomac River to Rocky Gorge Reservoir	Route #1
Potomac River to Occoquan Reservoir	Route #3
Potomac River to Beaverdam Reservoir	Route #1
Shenandoah River to Occoquan Creek	Route #1

The analysis procedure was performed in two parts. Since there were two choices of interconnection projects that would put water into the Occoquan Reservoir, the first optimization run consisted of analyzing all projects with the Shenandoah to Occoquan excluded. Part two analyzed all projects with the Potomac - Occoquan excluded. This was necessary information to evaluate the full impact of each project with regard to need.

In addition to the optimization analysis a separate analysis was performed for the Occoquan to determine the most desirable interconnection of the three that were available; (1) Potomac River - Occoquan, (2) Shenandoah River - Broad Run, and (3) Potomac River - Cub Run. A more detailed discussion of this special investigation can be found in Annex E-1.

Results

Once the optimization model input data were identified or developed several model runs were made in order to determine the optimum number of 30-day time periods to analyze for the 1930-1932 drought period. The results of these run indicated that the optimum condition to analyze would be seventeen 30-day periods between July 1930 through December 1931. This period allowed not only for impacts to be evaluated for the most severe drought period in the summer of 1930 but also the drought's impact the following summer.

Generally, the model determined which projects were needed to satisfy the demands and the required pipe diameters for 1980, 2000, and 2030. The results of the engineering optimization analysis for the benchmark years 1980, 2000, and 2030 are presented in Tables E-19 and E-20. Table E-19 shows the optimum network configuration with the Shenandoah - Occoquan route excluded. From this table it can be seen that in the year 1980 two pipelines will be required and by the year 2000 all three routes would be required. Flow capacities of these pipes varied for 3 mgd to about 45 mgd. These same similar results can be obtained from Table E-20 which excludes the Potomac - Occoquan raw water interconnection route.

It should be stressed that all results obtained from the model represented only a theoretical conclusion and did not necessarily indicate the most practical way to operate from the water supply agencies point of view. As an example: the MWA reservoirs ended the drought period with zero usable storage. This type of operation is fine provided the water suppliers, like the mathematical model, know exactly how long and intense a drought will be prior to its start; or, in other words, the model has perfect foresight. Unfortunately this is not the case and, therefore, the results obtained are not realistic from a water supplier's viewpoint. However, the results do serve as a very valuable tool upon which planning decisions can be made to determine which raw water interconnection projects are essential from a regional water supply evaluation viewpoint.

CONCLUSIONS

As a result of the engineering and environmental impact analysis performed, several conclusions concerning raw water interconnections and their role in helping solve the MWA Water Supply problem on a 30-day basis could be made. These conclusions are as follows:

a. The operation of raw water interconnections primarily affect those water service areas which depend on the Potomac River flow as a water supply source.

b. Existing storage facilities in the WSSC and FCWA systems are an integral part in the operation of raw water interconnections as they allow for storage of excess Potomac River flows.

TABLE E-19

30-DAY OPTIMIZATION MODEL SOLUTION WITH SHENANDOAH - OCCOQUAN ROUTE EXCLUDED

Pipeline	Demand Year		Design Flow Capacity (mgd)	
	1980	2000	2030	
Potomac - Patuxent	5.8	5.8	9	(reversible)
Potomac - Goose	0	3	21	
Potomac - Occoquan	24.5	34.5	44.8	(reversible)

TABLE E-20

30-DAY OPTIMIZATION MODEL SOLUTION WITH POTOMAC - OCCOQUAN ROUTE EXCLUDED

Pipeline	Demand Year		Design Flow Capacities (mgd)	
	1980	2000	2030	
Potomac - Patuxent	5.8	5.8	34	(Reversible)
Potomac - Goose	0	3	28	
Shenandoah - Occoquan	24.5	34.5	39.4	

c. Raw water interconnections are flexible in that they take advantage of existing treatment facilities at both ends of the pipeline. Reversibility of the system increases its utility.

d. In order for raw water interconnections to operate effectively, some regional coordination among the Potomac River users is required. This would be in addition to the Low Flow Allocation Agreement.

e. Raw water interconnections are expensive projects and are disruptive to the environment. However these impacts are generally not long lasting.

f. The Potomac-Beaverdam interconnection can solve problems specific to the Fairfax City water service area; however it provides no benefits to its surrounding water service areas.

g. Three ways were examined to run raw water interconnections to the Occoquan Reservoir (Potomac-Occoquan, Shenandoah-Occoquan and Potomac-Cub Run). In regards to flexibility, only the Potomac-Occoquan route would be reversible and could maximize both the water treatment plant at the reservoir and at the Potomac River.

Based on these conclusions, the raw water interconnections were screened from five to two. It was observed that two of the raw water interconnection routes under consideration for the FCWA (Potomac River to Cub Run #1 and Shenandoah River to Broad Run Route #1) did not provide the capability of linking the river or reservoir source with both treatment plants. Since the two routes did not have this flexibility nor could they provide cost-effective when analyzed in combination with additional one-way pipelines to the FCWA pipelines to the FCWA Potomac River Treatment Plant or expanded Occoquan Treatment facilities, only the reversible Potomac River to Occoquan Reservoir raw water interconnections project was retained for design and cost. The Potomac to Beaverdam Reservoir project (City of Fairfax) is considered further in Appendix I - Outlying Service Areas.

In light of these decisions therefore, the raw water interconnection projects selected for design and detailed cost as part of the MWA Raw Water Interconnection scheme were:

(a) Potomac River to Rocky Gorge Reservoir Reversible Route #1 and

(b) Potomac River to Occoquan Reservoir Route #3.

DESIGN AND DETAILED COST OF FINAL RAW WATER INTERCONNECTION ROUTES

In order to allow for greater flexibility in selecting the design capacity of the final two raw water interconnections being considered, the Baltimore District contracted with the consulting engineering firm of Hayes, Seay, Mattern, and Mattern to develop construction costs for pipelines corresponding to the following diameters: 36, 48, 54, and 90 inches.

Pump stations that were anticipated to be an integral part of each line were costed for pump capacities ranging from 10 to 180 million gallons per day (mgd). Operation and maintenance (O&M) costs were also developed. It should be noted that the construction costs developed for this analysis were based on non-site specific concept designs for the two pipeline projects. The following sections presents the methodology used in developing the project costs, followed by a presentation of the final cost estimates and the plan and profile drawings.

METHODOLOGY

Construction Cost - Pipelines

The pipeline construction costs were determined by developing unit costs ($/LF) for various pipeline sizes traversing six types of terrain found along the proposed alignments. The final construction cost would then be a function of the unit costs, plus add-on items such as rock excavation, valves, and thrust blocks. The following paragraphs define the different types of construction terrain and the type of construction required in each area.

Open Areas. These areas were defined as being undeveloped and having few or no buildings, and include such areas as golf courses, farm land, fields, and, cleared utility rights-of-way. For open areas, it was assumed that sufficient space would be available for unhindered movement of equipment and materials. Construction would include open-cut excavation with no sheeting, gravel bedding, standard compacted backfill at least four feet over the pipe crown, and seeding of the disturbed area.

Woods. These areas were defined as having few or no buildings and consisting of forests, orchards, and uncleared utility rights-of-way. Construction in wooded areas would be similar to open areas except that clearing and grubbing would be required across the entire right-of-way.

Developed. These areas were defined as containing moderate to high density development, and included residential, commercial, institutional and industrial land uses. Construction in these areas was assumed to require extensive relocation of existing utilities, tight sheeting, and pavement replacement.

Road Crossings. This category includes State primary routes, secondary roads, city streets, and paved roads in subdivisions. Construction in this category would include open-cut excavation and pavement replacement.

Highway and Railroad Crossings. A linear plate tunnel would be required across all U.S. highway routes, Interstate routes, and railroads.

Stream Crossings. Traversing all perennial and intermittent streams would involve stream diversion, dewatering, and concrete encasement.

The following paragraphs describe the materials and tasks involved in the construction of a pipeline. Also presented is a discussion of how the construction item was evaluated to develop the pipeline unit costs for the different types of terrain being traversed.

Pipe Material. Four types of material were investigated: concrete cylinder pipe, cement-lined welded steel pipe, cement-lined ductile iron pipe, and reinforced plastic pipe. Vendors and manufacturers were requested to furnish unit prices for pipe material delivered free on board (F.O.B.) to the Metropolitan Washington Area. Working pressures were assumed to be in the 250 to 300 pounds per square inch range. The most competitive pipe material was the reinforced plastic, followed by concrete cylinder, ductile iron, and steel. This generally held true for all pipe diameters. The average unit price of all four types of pipe was used as the basis for the engineering cost estimate.

Excavation and Backfill. This item included the cost of excavating and backfilling a trench for the new water main, as well as many incidentals, including minor utility relocations, minor stream crossings, erosion control measures, minor dewatering operations, minor reseeding and sodding, harnessing and blocking, testing, and restoration of disturbed areas. The number of cubic yards per linear foot (CY/LF) of excavation required for each pipe diameter was determined assuming four feet of cover over the top of the pipe, and using the Washington Suburban Sanitary Commission (WSSC) standard trench widths for various pipe sizes. The cost per cubic yard of excavation was determined by averaging bid prices for projects in the Metropolitan Washington Area (MWA).

Installation. The bid prices for furnishing and installing pipe on several projects in the MWA were averaged; and from this average, the estimated cost of the pipe material was subtracted to determine the installation cost. For the raw water lines, it was found that installation costs were 41% of the total bid price for 36" pipe, and 50% for 90" pipe. In developed areas, the installation cost increased considerably because of the cost of relocating existing utilities and structures such as water lines, sewer laterals, gas lines, telephone lines, power lines, storm sewers, and paved driveways. It was assumed that much of the excavation in developed areas would be done by hand, increasing the cost of

installation even further. Unit prices for utility line replacement and hand excavation were obtained from Means Building Construction Cost Data. Unit prices for pavement replacement were obtained from bid prices for previous projects in the MWA.

Dewatering. Costs for dewatering were based on unit prices from Means Building Construction Cost Data for pumping and cofferdam construction. It was assumed that the typical stream was twenty feet wide and that each crossing would take approximately three days to complete.

Pavement Restoration. This item includes the cost of providing a temporary patch for the roadway surface to allow for settlement, as well as the installation of permanent pavement over the trench. The average square yard price for pavement restoration on several projects in the MWA was used as the basis for repaving costs. The area per linear foot was based on the WSSC standard trench width plus 1.5 feet.

Clearing and Grubbing. The cost for this item was based on unit prices in Means Building Construction Cost Data for cutting and chipping medium trees and grubbing and removing stumps. Construction rights-of-way of 44 feet for 90-inch pipe, 32 feet for 54-inch and 48-inch pipe, and 27 feet for 36-inch pipe were assumed as the minimum clearing widths.

Concrete Encasement. This item includes pipe material, excavation and backfill, installation, and concrete. Unit costs for the initial three items have been discussed previously. The unit price (in dollar per cubic yard) for concrete was based on the average of previous bid prices for projects in the MWA. The volume of concrete per linear foot was based on WSSC standards for concrete encasements.

Tunneling. This item covers complete installation of the tunnel including the pipe material, installation, access pits, and tunneling shields. The size of the tunnel was based on a clearance of 2.5 feet from the outside top of pipe to the crown of the tunnel. The unit costs were developed from a previous study which used bid prices, and were checked by comparison with other bid prices from the MWA.

Reseeding. Additional costs are required for seeding because of the large areas that are expected to be involved. This item was based on unit prices (in dollars per square yard) for fine grading, lime, fertilizer, and seeding, as listed in Means Building Construction Cost Data. Construction rights-of-way of 44 feet for 90-inch pipe, 32 feet for 54-inch and 48-inch pipe, and 27 feet for 36-inch pipe were assumed as the minimum seeding widths.

In addition to the previous items that entered into the development of the $/LF costs, the total pipeline costs also included additional costs for rock excavation, and relief valves, blow-off valves, valve vaults, and thrust blocks. Rock excavation unit costs were determined from an analysis of previous bid prices in the MWA, and the quantities were estimated from a knowledge of existing rock outcrops in the MWA. Air relief and blow-off valves are located at the high and low points of a pipeline, respectively. Unit costs were developed from previous bid prices in the MWA, and the number of required valves was determined from the route profiles. The costs of valve vaults were also determined from previous bid prices, and they were located at branches and junctions in the pipeline. The unit cost of thrust blocks to anchor the pipeline at sharp bends were developed from previous bid prices in the MWA, and the number of required blocks was obtained from the proposed horizontal alignment.

A summary of the pipeline unit costs and add-on items are presented in Table E-21 for the four alternative pipe diameters, and for the six alternative types of construction terrain considered. These pipeline unit costs are plotted on Figure E-4 to show how unit costs for other pipe diameters were determined. All cost estimates are at October 1981 price levels.

Construction Costs - Pump Stations

Construction costs for the raw water pumping stations were developed based on non-site specific design concepts and will need to be refined when site specific criteria such as topography, soil and subsurface condition, availability of utilities, accessibility and construction difficulties have been determined. Additionally, since various sizes of pipelines were evaluated, it was decided to develop pump station costs for capacities ranging form 10 mgd to 180 mgd for each pipeline.

Construction materials and some pump station equipment costs were based on average unit prices taken from Engineering New Record (ENR). Other equipment costs, such as pumps and motors, valves, interior piping, and traveling bridge cranes were obtained from manufacturers who quoted equipment prices and costs for shipment to the Washington area. Man-hour requirements for pump and motor installation were obtained from Richardson's Process Plant Construction Estimating Standards 1976-1977 Edition.

Costs for architectural civil, electrical, structural, and heating and ventilating items have been included in the cost estimate. Contractor's overhead and profit, site and design contingencies, bonding costs, and costs for civil-electrical coordination have been added to arrive at a total construction cost. Cost for the civil-electrical coordination were included because experience has indicated that proj cts involving process equipment such as pumps, motors, and control systems require field coordination between the various trades installing the equipment. This coordination is required to insure compatibility between equipment and control systems and to insure that pumping operations will function in accordance with design specifications. Figure E-5 graphically presents the construction cost versus pumping capacity for all four of the pump stations considered. These costs are at October 1981 price levels.

Operation and Maintenance Costs

The operation and maintenance (O&M) costs for each pump station were developed on a daily basis using different pumping capacities and total dynamic head (TDH). For operational purposes it was assumed that the stations would operate for one continuous 24 hour period at 100 percent capacity. O&M costs were composed of primarily two types of costs: (a) fixed costs which include fixed maintenance costs and spare parts and (b) variable maintenance costs which include energy and operator costs.

The fixed maintenance costs assumed that 32 hours of operator time would be required each month for equipment exercising, equipment checks, and lubrication. This time would be required regardless of the normal operation time. The spare parts cost was derived assuming the repair parts requirements for a pump to be 25 percent of the first cost of the pump over a ten year time period. A first cost of different pump sizes was determined from price quotations from various manufacturers. The 25 percent spare parts cost was calculated and applied to an ordinary Annuity/Present Value equation with a 6 7/8 annual interest rate. The result was the cost per day required for spare parts as a function of pump station capacity.

TABLE E-21

UNIT COSTS FOR RAW WATER PIPELINE CONSTRUCTION
(OCTOBER 1981 PRICE LEVELS)

CONSTRUCTION ITEMS - $/LF

Pipe Dia.	Constr. Terrain	Material	Exc. & Bkfill.	Inst.	Dewater.	Pave. Restor.	Clear & Grub	Conc. Encase	Tunnel	Reseed.	Bedding	Total	Rock Evc.	Air Relief Valves	Blow-off Valves	Valve Vaults	Thrust Blocks
36"	A	63	23	25	0	0	0	0	0	4.10	5.90	121	$51/LF	$6,700/EA	$2,500/EA	$14,500/EA	Cost
	B	63	23	25	0	0	2.10	0	0	4.10	5.90	123					depends
	C	63	(1)	131	0	(1)	0	0	0	(1)	5.90	200					on
	D	63	23	25	0	33	0	0	0	0	5.90	150					route
	E	(2)	0	(2)	0	0	0	0	796	0	0	796					and
	F	(3)	0	(3)	142	0	0	182	0	0	0	324					capacity
48"	A	98	32	42	0	0	0	0	0	4.80	9.90	187	$72/LF	$6,700/EA	$2,500/EA	$24,100/EA	Cost
	B	98	32	42	0	0	2.50	0	0	4.80	9.90	189					depends
	C	98	(1)	206	0	(1)	0	0	0	(1)	9.90	314					on
	D	98	32	42	0	41	0	0	0	0	9.90	223					route
	E	(2)	0	(2)	0	0	0	0	882	0	0	882					and
	F	(3)	0	(3)	170	0	0	275	0	0	0	445					capacity
54"	A	118	37	55	0	0	0	0	0	4.80	11.10	226	$83/LF	$14,100/EA	$2,500/EA	$30,200/EA	Cost
	B	118	37	55	0	0	2.50	0	0	4.80	11.10	228					depends
	C	118	(1)	251	0	(1)	0	0	0	(1)	11.10	380					on
	D	118	37	55	0	42	0	0	0	0	11.10	263					route
	E	(2)	0	(2)	0	0	0	0	937	0	0	937					and
	F	(3)	0	(3)	173	0	0	330	0	0	0	503					capacity
90"	A	291	68	118	0	0	0	0	0	6.60	22.70	506	$152/LF	$20,900/EA	$17,900/EA	$119,300/EA	Cost
	B	291	68	118	0	0	3.50	0	0	6.60	22.70	510					depends
	C	291	(1)	595	0	(1)	0	0	0	(1)	22.70	909					on
	D	291	68	118	0	56	0	0	0	0	22.70	556					route
	E	(2)	0	(2)	0	0	0	0	1525	0	0	1525					and
	F	(3)	0	(3)	296	0	0	685	0	0	0	981					capacity

*A Open Area
B Woods
C Developed
D Road Crossing
E Highway and Railroad Crossings
F Stream Crossings

Footnotes
(1) Included in installation cost
(2) Included in tunneling cost
(3) Included in concrete encasement cost

FIGURE E-4

PIPELINE UNIT COST CURVES FOR VARIOUS PIPELINE CONSTRUCTION CATEGORIES

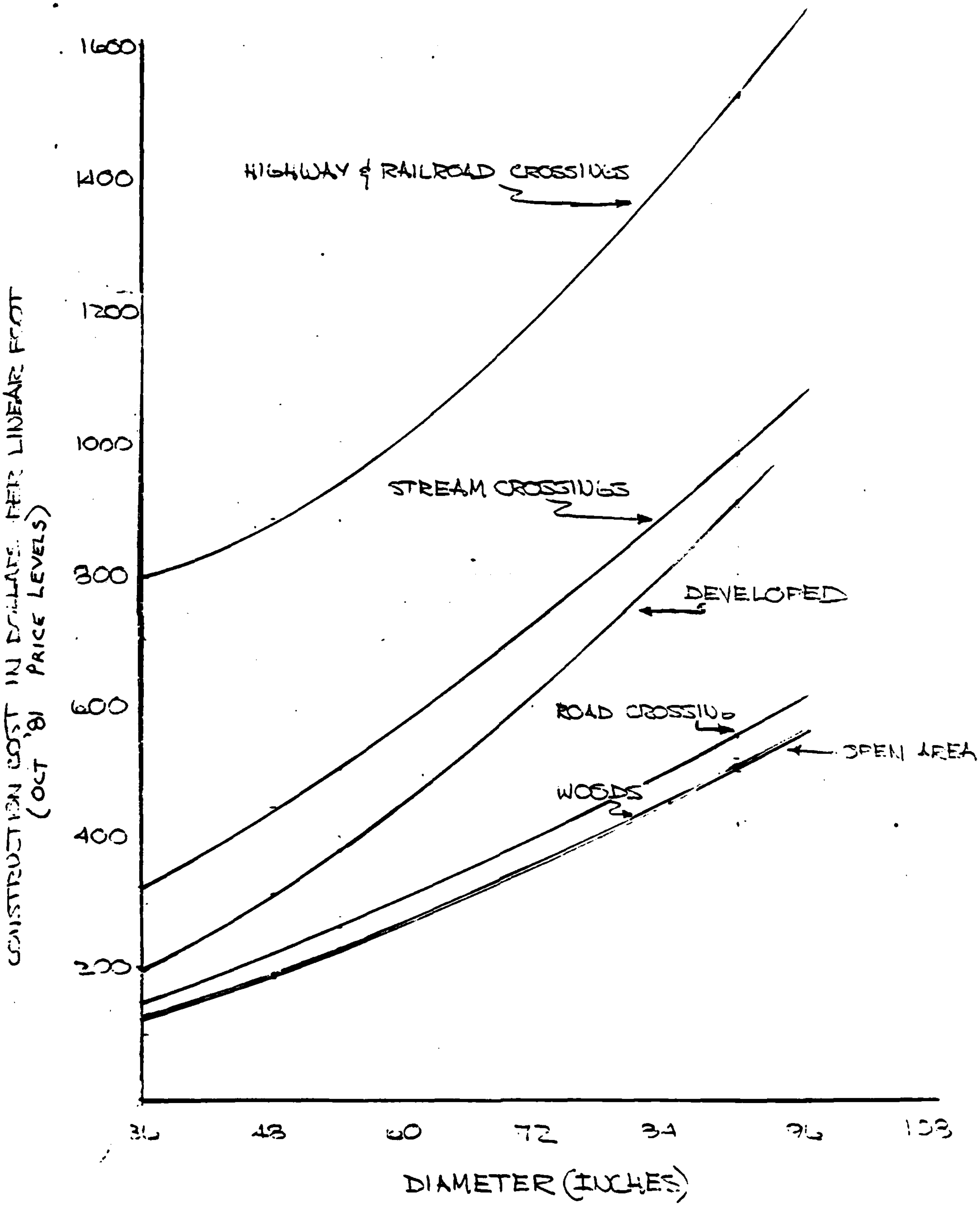
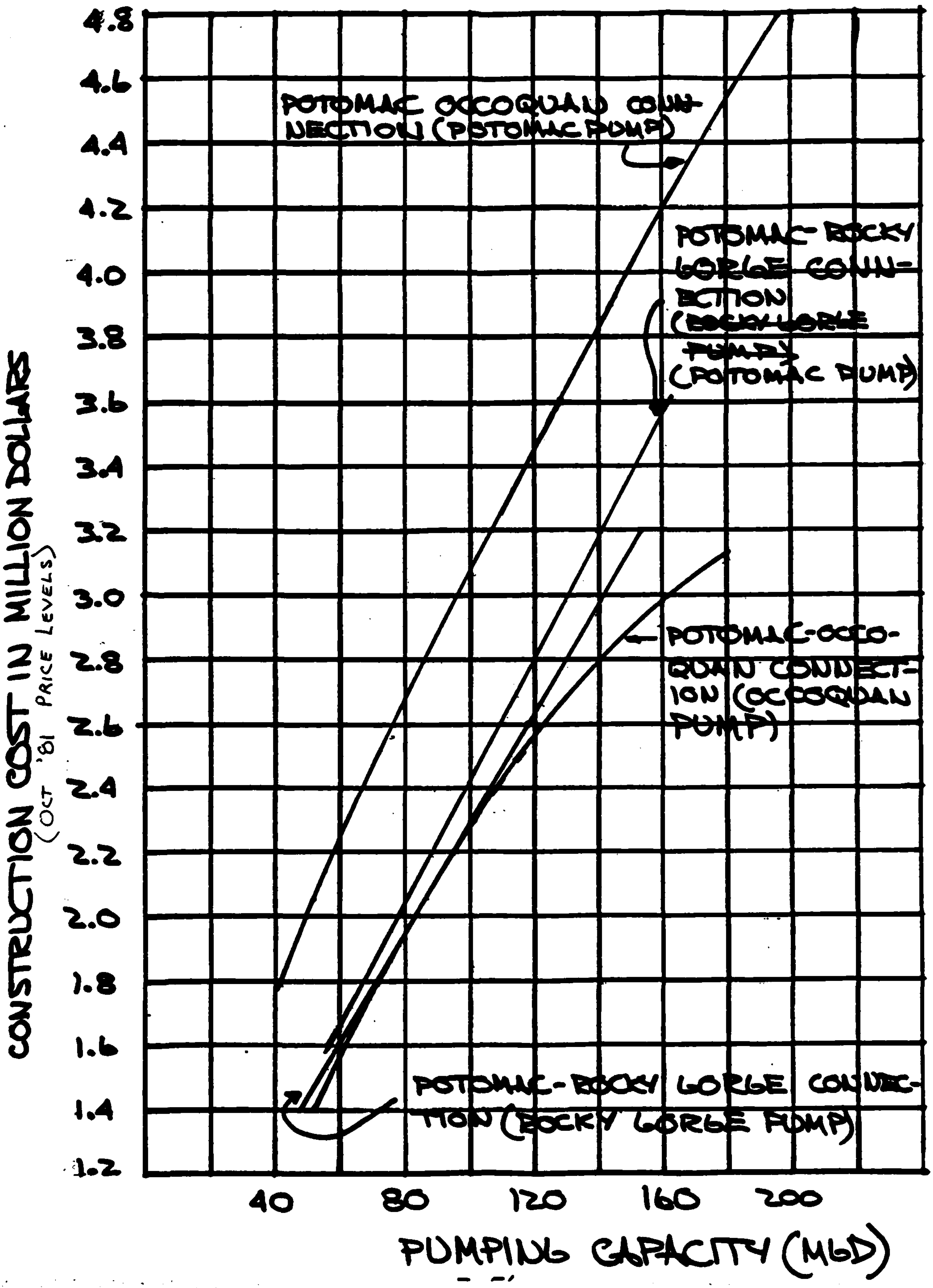


FIGURE E-5

PUMP STATION CONSTRUCTION COST CURVE



The energy costs were derived using a standard equation with pumping capacity, TDH, and power costs assuming an 80 percent pump efficiency, and a 95 percent motor efficiency. The power cost used was the average rate for WAD electrical costs for FY 78 and the PEPCO rate schedule issued 7 July 1978. The operator time was obtained by assuming the operator would be at the station 0.3 hours for every hour of operation. Wage rates for a pump operator and supervisor was obtained from the WSSC and Falls Church pay scales, with a 25 percent fringe benefit cost added.

Figure E-6 graphically presents the total pump station O&M costs (sum of the fixed maintenance, variable maintenance, energy and operation time costs) corresponding to a total dynamic head delivered for dollars per day versus millions of gallons per day pumped. These costs were escalated from December 1978 to October 1981 price levels by the ENR Construction Cost Index.

Based on the data collected for actual pipeline projects, the average annual operation and maintenance cost of a pipeline was estimated to be one-tenth percent of the construction cost. The major replacement cost of the pumps and the pipelines were estimated based on construction costs and O&M costs. These costs varied from $6,500 to $13,000 per year depending upon the size of the pipeline and the pump.

RESULTS

The final design criteria governing the sizing of the raw water interconnection pipelines and components were arrived at based on decisions made at meetings between the Corps and the Metropolitan Washington Area's water supply agencies during the early-action phase of study. It was agreed at these meetings that in order for the projects to operate efficiently, the following criteria should be satisfied: The capacity of the pipeline and pump station should be such that the system can deliver sufficient volume of water necessary to meet the projected deficit between a 100-year recurrence 7-day duration low flow on the Potomac River including releases from Bloomington Reservoir and projected August 7-day demands under Conservation Scenario 3; and maintain a sufficient volume of water in the Potomac River to provide for 100 mgd flowby past the Little Falls gaging station.

Using the preceeding design criteria, the final design flows and pipe diameters required for both the Potomac River to Rocky Gorge and Potomac River to Occoquan Reservoir raw water interconnection projects were developed. See Table E-22.

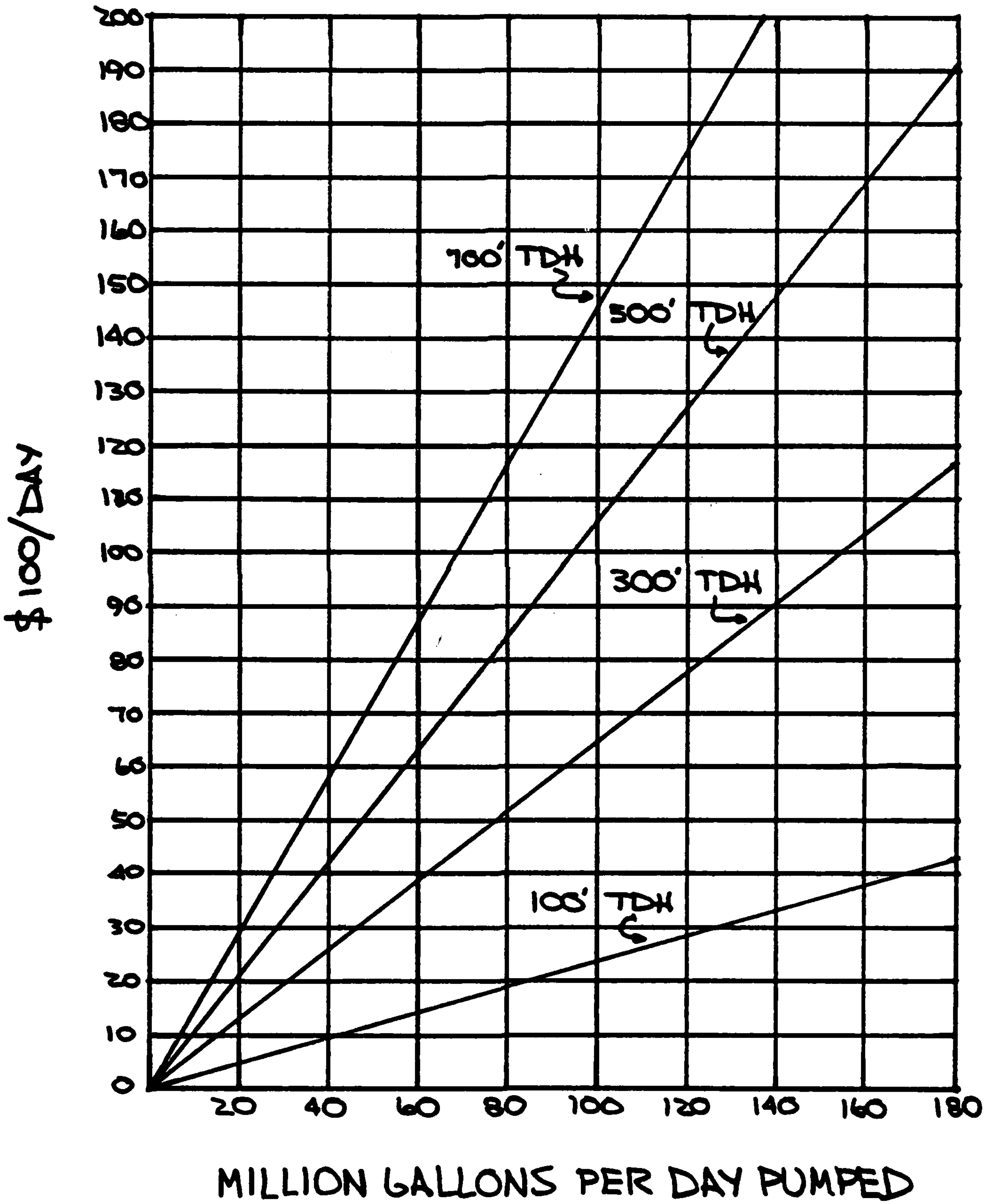
TABLE E-22

FINAL ALTERNATIVE DESIGN FLOWS AND PIPE DIAMETERS FOR RAW WATER INTERCONNECTIONS

Potomac-Rocky Gorge		Potomac-Occoquan	
Flow (mgd)	Dia (in.)	Flow (mgd)	Dia (in.)
60	54	65	60
90	66	75	60
180	96	90	66
		180	96

FIGURE E-6

OPERATION & MAINTENANCE COST CURVE
(OCTOBER 1981 PRICE LEVELS)



Once the project design flows and pipe diameters were determined, costs corresponding to pipeline construction, pump station construction, and operation and maintenance costs were generated by interpolating the general cost relationships discussed in the previous paragraphs. The following section presents the estimated construction and operation and maintenance costs for each project. All costs are listed separately for pipeline construction, pump station construction, land acquisition, and operation and maintenance.

Table E-23 presents in summary form the project costs for the alternative raw water interconnections evaluated for the Potomac River to Rocky Gorge Reservoir and the Potomac River to Occoquan Reservoir. Included in the table are construction, O&M, and major replacement costs. Tables E-24 through E-30 present detailed cost breakdowns for each of the projects (refer to the bottom of Table E-23 to determine the appropriate table number).

The last portion the this chapter includes general plans and profiles for the two final interconnections. Figures E-7 and E-8 show the general route of the Potomac-Rocky Gorge pipeline, and Figures E-9 to E-11 show the pipeline profile. Figures E-12 to E-15 show the general route of the Potomac-Occoquan pipeline, and Figures E-16 to E-19 show the pipeline profile.

TABLE E-23

RAW WATER INTERCONNECTION PROJECT COSTS ($1,000)
(October 1981 Prices in $1,000)

Cost Item	P[illegible]mac River-Rocky Gorge Reservoir			Potomac River-Occoquan Reservoir			
	6[illegible] mgd 54"	90 mgd 66"	180 mgd 96"	65 mgd 60"	75 mgd 60"	90 mgd 66"	180 mgd 96"
Pipeline	38,138	52,475	95,928	56,486	56,486	65,984	118,767
Pump Stations	3,270	4,350	7,560	3,970	4,440	4,990	7,690
Land	14,100	14,100	14,100	14,100	14,100	14,100	14,100
Final Design, P&S, Const S&I	4,441	5,674	9,407	5,964	6,002	6,806	11,245
Total Capital Costs	59,949	76,599	126,995	80,520	81,028	91,880	151,802
Daily Potomac Pump Station O&M Costs	6.6	9.7	19.2	7.1	8.3	9.8	19.5
Daily Reservoir Pump Station O&M Costs	5.3	7.8	15.4	8.0	9.5	10.9	21.9
Annual Pipeline O&M Costs	38	53	96	56	56	66	119
Annual Major Replacement Costs	8	10	12	10	10	11	13
Table Showing Detailed Cost Estimate	E-24	E-25	E-26	E-27	E-28	E-29	E-30

TABLE E-24

POTOMAC RIVER - ROCKY GORGE RESERVOIR
RAW WATER INTERCONNECTION

PROJECT COSTS (October 1981 Prices)

Design Flow - 60 mgd   Pipe Diameter 54 inches

I. PIPELINE COST

Construction Terrain	Quantity		Unit Cost		Estimated Cost
A	43,530	LF @	$226	=	$9,837,780
B	57,600	LF @	228	=	13,132,800
C	21,660	LF @	380	=	8,230,800
D	660	LF @	263	=	173,580
E	450	LF @	937	=	421,650
F	500	LF @	503	=	251,500
			Subtotal		$32,048,110

Add-On Items

Rock Excavation	6,200	LF @	$83	=	$514,600
Air Relief Valves	27	EA @	14,100	=	380,700
Blow-Off Valves	33	EA @	2,500	=	82,500
Valve Vaults	2	EA @	30,200	=	60,400
Thrust Blocks		LS	77,200	=	77,200
			Subtotal		$1,115,400

Net Pipeline Construction Cost	$33,163,510
Contingencies (15%)	4,974,490
Total Pipeline Construction Cost	$38,138,000

II. PUMP STATION COST

Potomac River to Rocky Gorge Reservoir	$1,680,000
Rocky Gorge Reservoir to Potomac River	1,590,000
Total Pump Station Cost	$3,270,000

III LAND COST

Land	$9,600,000
Improvements	1,900,000
Severence	1,300,000
Relocation of Homes and Businesses	1,300,000
Total Land Cost	$14,100,000

TABLE E-24 (Continued)

IV TOTAL CAPITAL COST

Pipeline		$38,138,000
Pump Stations		3,270,000
Land		14,100,000
	Subtotal	$55,508,000
Final Design, Plans & Specifications and Construction Supervision & Inspection (8%)		4,441,000
	Total Capital Cost	$59,949,000

V O&M COST (PUMP STATIONS ONLY)

	Personnel $/Day	Energy $/Day	Fixed Maint $/Day	Variable Maint. $/Day	Total $/Day
Potomac to Rocky Gorge	180	6,400	25	25	6,630
Rocky Gorge to Potomac	180	5,100	25	25	5,330

VI O&M COST (PIPELINE ONLY)

$38,138,000 X 0.001 = $38,000/YR

VII MAJOR REPLACEMENT COST

$8,000/YR

TABLE E-25

POTOMAC RIVER - ROCKY GORGE RESERVOIR
RAW WATER INTERCONNECTION

Project Costs (October 1981 Prices)

Design Flow - 90 mgd   Pipe Diameter - 66 inches

I PIPELINE COST

Construction Terrain	Quantity		Unit Cost		Estimated Cost
A	43,530	LF @	$310	=	$13,494,300
B	57,600	LF @	313	=	18,028,800
C	21,660	LF @	530	=	11,479,800
D	660	LF @	352	=	232,320
E	450	LF @	1,090	=	490,500
F	500	LF @	640	=	320,000
			Subtotal		$44,045,720
Add-On Items					
Rock Excavation	6,200	LF @	$106	=	$657,200
Air Relief Values	27	EA @	16,300	=	440,100
Blow-Off Valves	33	EA @	7,600	=	250,800
Valve Vaults	2	EA @	60,000	=	120,000
Thrust Blocks		LS	116,000	=	116,600
			Subtotal		$1,584,700
			Net Pipeline Construction Cost		$45,630,420
			Contingencies (15%)		6,844,580
			Total Pipeline Construction Cost		$52,475,000

II PUMP STATION COST

Potomac River to Rocky Gorge Reservoir	$2,240,000
Rocky Gorge Reservoir to Potomac River	2,110,000
Total Pump Station Cost	$4,350,000

III LAND COST

Land	$9,600,000
Improvements	1,900,000
Severence	1,300,000
Relocation of Homes and Businesses	1,300,000
Total Land Cost	$14,100,000

TABLE E-25 (continued)

IV TOTAL CAPITAL COST

Pipeline		$52,475,000
Pump Stations		4,350,000
Land		14,100,000
	Subtotal	$70,925,000
Final Design, Plans & Specifications and Construction Supervision & Inspections (8%)		5,674,000
	Total Capital Cost	$76,599,000

V O&M COST (PUMP STATIONS ONLY)

	Personnel $/Day	Energy $/Day	Fixed Maint $/Day	Variable Maint $/Day	Total $/Day
Potomac to Rocky Gorge	180	9,500	25	40	9,745
Rocky Gorge to Potomac	180	7,600	25	40	7,845

VI O&M COST (PIPELINE ONLY)

$52,475,000 X 0.001 = $53,000/YR

VII MAJOR REPLACEMENT COST $10,000/YR

TABLE E-26
POTOMAC RIVER - ROCKY GORGE RESERVOIR
RAW WATER INTERCONNECTION

PROJECT COSTS (October 1981 Prices)

Design Flow - 180 mgd   Pipe Diameter - 96 inches

I PIPELINE COST

Construction Terrain	Quantity		Unit Cost		Estimated Cost
A	43,530	LF @	$560	=	$24,376,800
B	57,600	LF @	564	=	32,486,400
C	21,660	LF @	1,020	=	22,093,200
D	660	LF @	615	=	405,900
E	450	LF @	1,660	=	747,000
F	500	LF @	1,080	=	540,000
			Subtotal		$80,649,300
Add-On Items					
Rock Excavation	6,200	LF @	$163	=	$1,010,600
Air Relief Valves	27	EA @	22,000	=	594,000
Blow-Off Valves	33	EA @	20,500	=	676,500
Valve Vaults	2	EA @	135,000	=	270,000
Thrust Blocks		LS	215,100	=	215,100
			Subtotal		$2,766,200
			Net Pipeline Construction Cost		$83,415,500
			Contingencies (15%)		12,512,500
			Total Pipeline Construction Cost		$95,928,000

II PUMP STATION COST

Potomac River to Rocky Gorge Reservoir	$3,930,000
Rocky Gorge Reservoir to Potomac River	3,630,000
Total Pump Station Cost	$7,560,000

III LAND COST

Land	$9,600,000
Improvements	1,900,000
Severence	1,300,000
Relocation of Homes and Businesses	1,300,000
Total Land Cost	$14,100,000

TABLE E-26 (continued)

IV TOTAL CAPITAL COST

Pipeline		$95,928,000
Pump Stations		7,560,000
Land		14,100,000
	Subtotal	$117,588,000
Final Design, Plans & Specifications and Construction Supervision & Inspection (8%)		9,407,000
	Total Capital Cost	$126,995,000

V O&M COST (PUMP STATIONS ONLY)

	Personnel $/Day	Energy $/Day	Fixed Maint $/Day	Variable Maint $/Day	Total $/Day
Potomac to Rocky Gorge	180	18,900	25	75	19,180
Rocky Gorge to Potomac	180	15,100	25	75	15,380

VI O&M COST (PIPELINE ONLY)

$95,928,000 X 0.001 = $96,000/YR

VII MAJOR REPLACEMENT COST $12,000/YR

TABLE E-27

POTOMAC RIVER - OCCOQUAN RESERVOIR
RAW WATER INTERCONNECTION

Project Costs (October 1981 Prices)

Design Flow - 65 mgd   Pipe Diameter - 60 inches

I PIPLINE COST

Construction Terrain	Quantity		Unit Cost		Estimated Cost
A	156,780	LF @	$265	=	$41,546,700
B	18,400	LF @	268	=	4,931,200
C	0	LF @	450	=	0
D	740	LF @	305	=	225,700
E	900	LF @	1,010	=	909,000
F	780	LF @	570	=	444,600
			Subtotal		$48,057,200

Add-On Items					
Rock Excavation	0	LF @	$94	=	0
Air Relief Valves	40	EA @	15,200	=	608,000
Blow-Off Valves	37	EA @	5,000	=	185,000
Valve Vaults	3	EA @	45,000	=	135,000
Thrust Blocks		LS	133,000	=	133,000
			Subtotal		$1,061,000

Net Pipeline Construction Cost	$49,118,200
Contingencies (15%)	7,367,800
Total Pipeline Construction Cost	$56,486,000

II PUMP STATION COST

Potomac River to Occoquan Reservoir	$2,300,000
Occoquan Reservoir to Potomac River	1,670,000
Total Pump Station Costs	$3,970,000

III LAND COST

Land	$10,200,000
Improvements	1,300,000
Severence	1,300,000
Relocation of Homes and Businesses	1,300,000
Total Land Cost	$14,100,000

TABLE E-27 (continued)

IV TOTAL CAPITAL COST

Pipeline		$56,486,000
Pump Stations		3,970,000
Land		14,100,000
	Subtotal	$74,556,000
Final Design, Plans & Specifications and Construction Supervision & Inspection (8%)		5,964,000
	Total Capital Cost	$80,520,000

V O&M COST (PUMP STATIONS ONLY)

	Personnel $/Day	Energy $/Day	Fixed Maint $/Day	Variable Maint. $/Day	Total $/Day
Potomac to Occoquan	180	6,900	25	30	7,135
Occoquan to Potomac	180	7,800	25	30	8,035

VI O&M COST (PIPELINE ONLY)

$56,486,000 X 0.001 = $56,000/YR

VII MAJOR REPLACEMENT COST $10,000/YR

TABLE E-28

POTOMAC RIVER - OCCOQUAN RESERVOIR
RAW WATER INTERCONNECTION

Project Costs (October 1981 Prices)

Design Flow - 75 mgd   Pipe Diameter - 60 inches

I PIPELINE COST

Construction Terrain	Quantity		Unit Cost		Estimated Cost
A	156,780	LF @	$265	=	$41,546,700
B	18,400	LF @	268	=	4,931,200
C	0	LF @	450	=	0
D	740	LF @	305	=	225,700
E	780	LF @	1,010	=	909,000
F	780	LF @	570	=	444,600

Add-On Items

Rock Excavation	0	LF @	$94	=	$0
Air Relief Valves	40	EA @	15,200	=	608,000
Blow-Off Valves	37	EA @	5,000	=	185,000
Valve Vaults	3	EA @	45,000	=	135,000
Thrust Blocks		LS	133,000	=	133,000
			Subtotal		$1,061,000
			Net Pipeline Construction Cost		$49,118,200
			Contingencies (15%)		7,367,800
			Total Pipeline Construction Cost		$56,486,000

II PUMP STATION COST

Potomac River to Occoquan Reservoir	$2,550,000
Occoquan Reservoir to Potomac River	1,890,000
Total Pump Station Cost	$4,440,000

III LAND COST

Land	$10,200,000
Improvements	1,300,000
Severence	1,300,000
Relocation of Homes and Businesses	1,300,000
Total Land Cost	$14,100,000

TABLE E-28 (Continued)

IV TOTAL CAPITAL COST

Pipeline		$56,486,000
Pump Stations		4,440,000
Land		14,100,000
	Subtotal	$75,026,000
Final Design, Plans & Specifications and Construction Supervision & Inspection (8%)		6,002,000
	Total Capital Cost	$81,028,000

V O&M COST (PUMP STATIONS ONLY)

	Personnel $/Day	Energy $/Day	Fixed Maint $/Day	Variable Maint. $/Day	Total $/Day
Potomac to Occoquan	180	8,100	25	35	8,340
Occoquan to Potomac	180	9,300	25	35	9,540

VI O&M COST (PIPELINE ONLY)

$56,486,000 x 0.001 = $56,000/YR

VII MAJOR REPLACEMENT COST $10,000/YR

TABLE E-29

POTOMAC RIVER - OCCOQUAN RESERVOIR
RAW WATER INTERCONNECTION

Project Costs (October 1981 Prices)

Design Flow - 90 mgd   Pipe Diameter - 66 inches

I PIPELINE COST

Construction Terrain	Quantity		Unit Cost		Estimated Cost
A	156,780	LF @	$310	=	$48,601,800
B	18,400	LF @	313	=	5,759,200
C	0	LF @	530	=	0
D	740	LF @	352	=	260,480
E	900	LF @	1,090	=	981,000
F	780	LF @	640	=	499,200
			Subtotal		$56,101,680
Add-On Items					
Rock Excavation	0	LF @	$106	=	$0
Air Relief Valves	40	EA @	16,300	=	652,000
Blow-Off Valves	37	EA @	7,600	=	281,000
Valve Vaults	3	EA @	60,000	=	180,000
Thrust Blocks		LS	163,000	=	163,000
			Subtotal		$1,276,200
			Net Pipeline Construction Cost		$57,377,880
			Contingencies (15%)		8,606,120
			Total Pipeline Construction Cost		$65,984,000

II PUMP STATION COST

Potomac River to Occoquan Reservoir	$2,840,000
Occoquan Reservoir to Potomac River	2,150,000
Total Pump Station Cost	$4,990,000

III LAND COST

Land	$10,200,000
Improvements	1,300,000
Severence	1,300,000
Relocation of Homes and Businesses	1,300,000
Total Land Cost	$14,100,000

TABLE E-29 (Continued)

IV TOTAL CAPITAL COST

Pipeline		$65,984,000
Pump Stations		4,990,000
Land		14,100,000
	Subtotal	$85,074,000
Final Design, Plans & Specifications, and Construction Supervision & Inspection (8%)		6,806,000
	Total Capital Cost	$91,880,000

V O&M COST (PUMP STATIONS ONLY)

	Personnel $/Day	Energy $/Day	Fixed Maint. $/Day	Variable Maint. $/Day	Total $/Day
Potomac to Occoquan	180	9,600	25	40	9,845
Occoquan to Potomac	180	10,700	25	40	10,945

VI O&M COST (PIPELINE ONLY)

$65,984,000 X 0.001 = $66,000/YR

VII MAJOR REPLACEMENT COST $11,000/YR

TABLE E-30

POTOMAC RIVER - OCCOQUAN RESERVOIR
RAW WATER INTERCONNECTION

Project Costs (October 1981 Prices)

Design Flow - 180 mgd   Pipe Diagram - 96 inches

I PIPELINE COST

Construction Terrain	Quantity		Unit Cost		Estimated Cost
A	156,708	LF @	$560	=	$87,756,480
B	18,400	LF @	564	=	10,377,600
C	0	LF @	1,020	=	0
D	740	LF @	615	=	455,100
E	900	LF @	1,660	=	1,494,000
F	780	LF @	1,080	=	842,400
			Subtotal		$100,925,580
Add-On Items					
Rock Excavation	0	LF @	$163	=	0
Air Relief Valves	40	EA @	22,000	=	880,000
Blow-Off Valves	37	EA @	20,500	=	758,500
Valve Vaults	3	EA @	135,000	=	405,000
Thrust Blocks		LS	306,000	=	306,000
			Subtotal		$2,349,500
			Net Pipeline Construction Cost		$103,275,080
			Contingencies (15%)		15,491,920
			Total Pipeline Construction Cost		$118,767,000

II PUMP STATION COST

Potomac River to Occoquan Reservoir		$4,550,000
Occoquan Reservoir to Potomac River		3,140,000
	Total Pump Station Cost	$7,690,000

III LAND COST

Land		$10,200,000
Improvements		1,300,000
Severence		1,300,000
Relocation of Homes and Businesses		1,300,000
	Total Land Cost	$14,100,000

TABLE E-30 (Continued)

IV TOTAL CAPITAL COST

Pipeline		$118,767,000
Pump Stations		7,690,000
Land		14,100,000
	Subtotal	$140,557,000
Final Design, Plans & Specifications, and Construction Supervision & Inspection (8%)		11,245,000
	Total Captital Cost	$151,802,000

V O&M COST (PUMP STATIONS ONLY)

	Personnel $/Day	Energy $/Day	Fixed Maint. $/Day	Variable Maint. $/Day	Total $/Day
Potomac to Occoquan	180	19,200	25	80	19,485
Occoquan to Potomac	180	21,600	25	80	21,885

VI O&M COST (PIPELINE ONLY)
$118,767,000 X 0.001 = $119,000,000/YR

VII MAJOR REPLACEMENT COST $13,000/YR

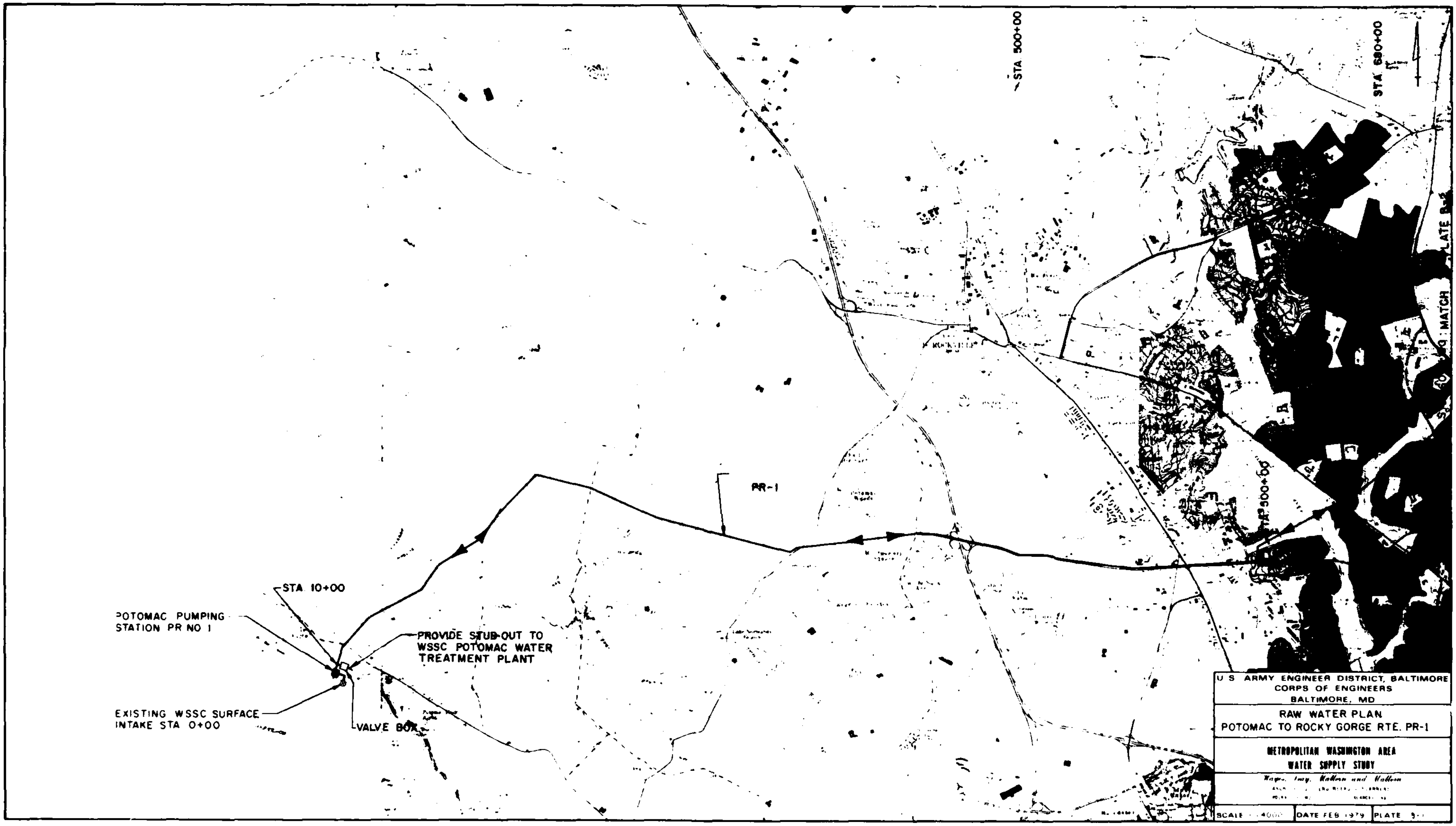

STA 500+00
STA 680+00
MATCH
PR-1
STA 500+00
STA 10+00
POTOMAC PUMPING STATION PR NO 1
PROVIDE STUB-OUT TO WSSC POTOMAC WATER TREATMENT PLANT
EXISTING WSSC SURFACE INTAKE STA 0+00
VALVE BOX
U S ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MD
RAW WATER PLAN
POTOMAC TO ROCKY GORGE RTE. PR-1
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
DATE FEB 1979

Figure E-7

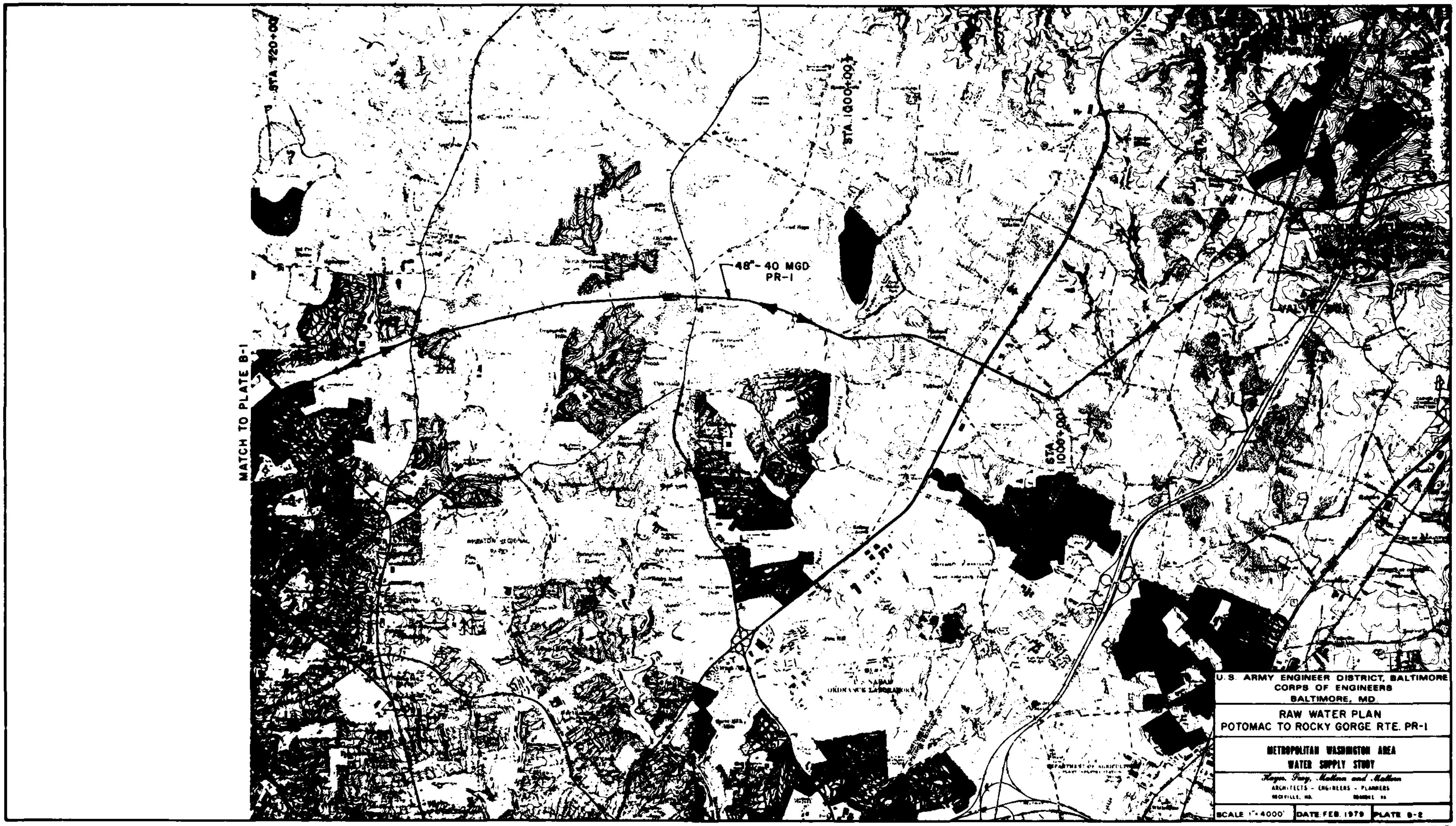

MATCH TO PLATE B-1
STA. 720+00
STA. 1000+00
48"- 40 MGD
PR-1
STA.
1000+00
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MD.
RAW WATER PLAN
POTOMAC TO ROCKY GORGE RTE. PR-1
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
Hayes, Seay, Mattern and Mattern
ARCHITECTS - ENGINEERS - PLANNERS
SCALE 1"=4000'
DATE FEB. 1979
PLATE B-2

Figure E-8

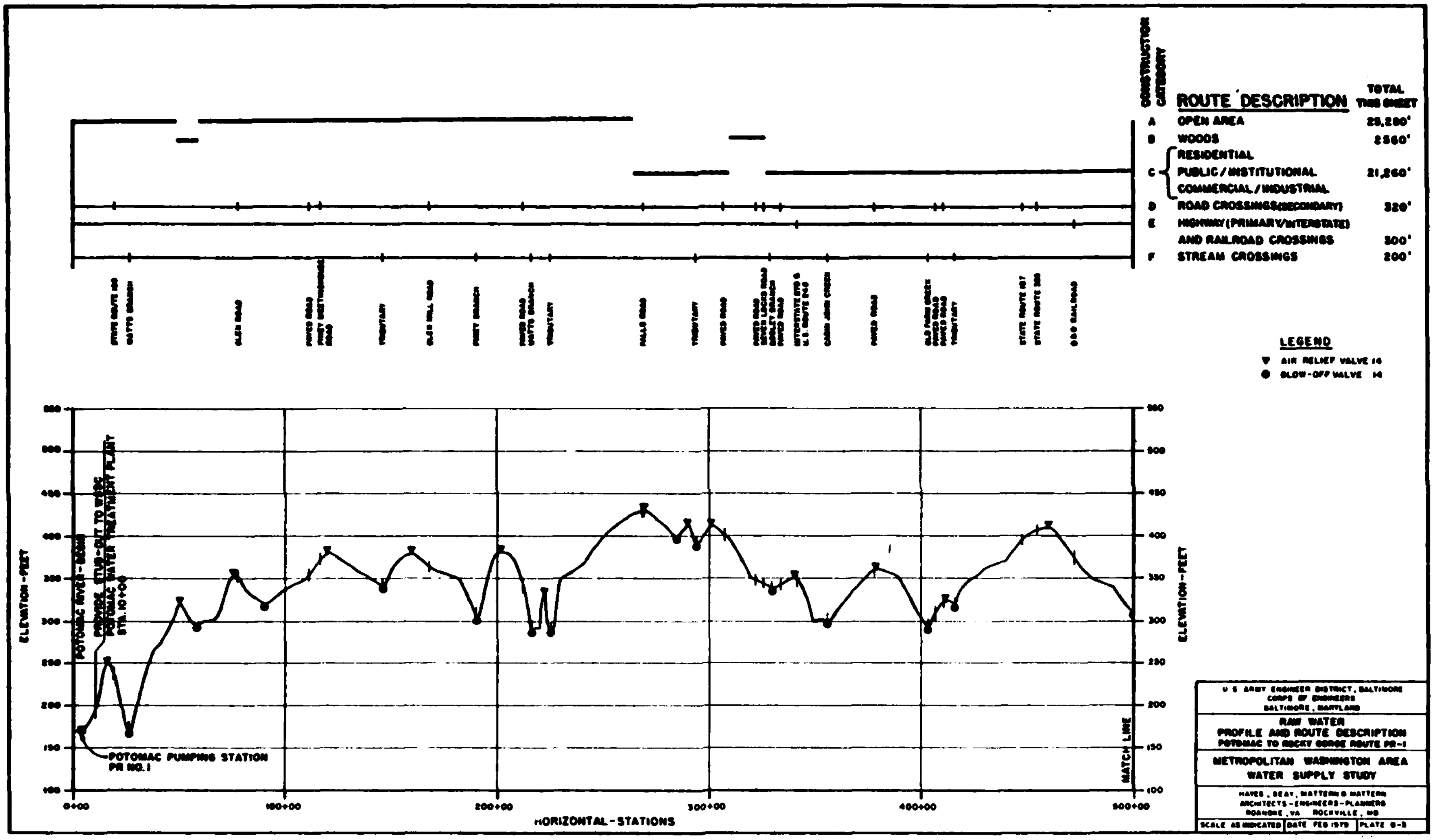
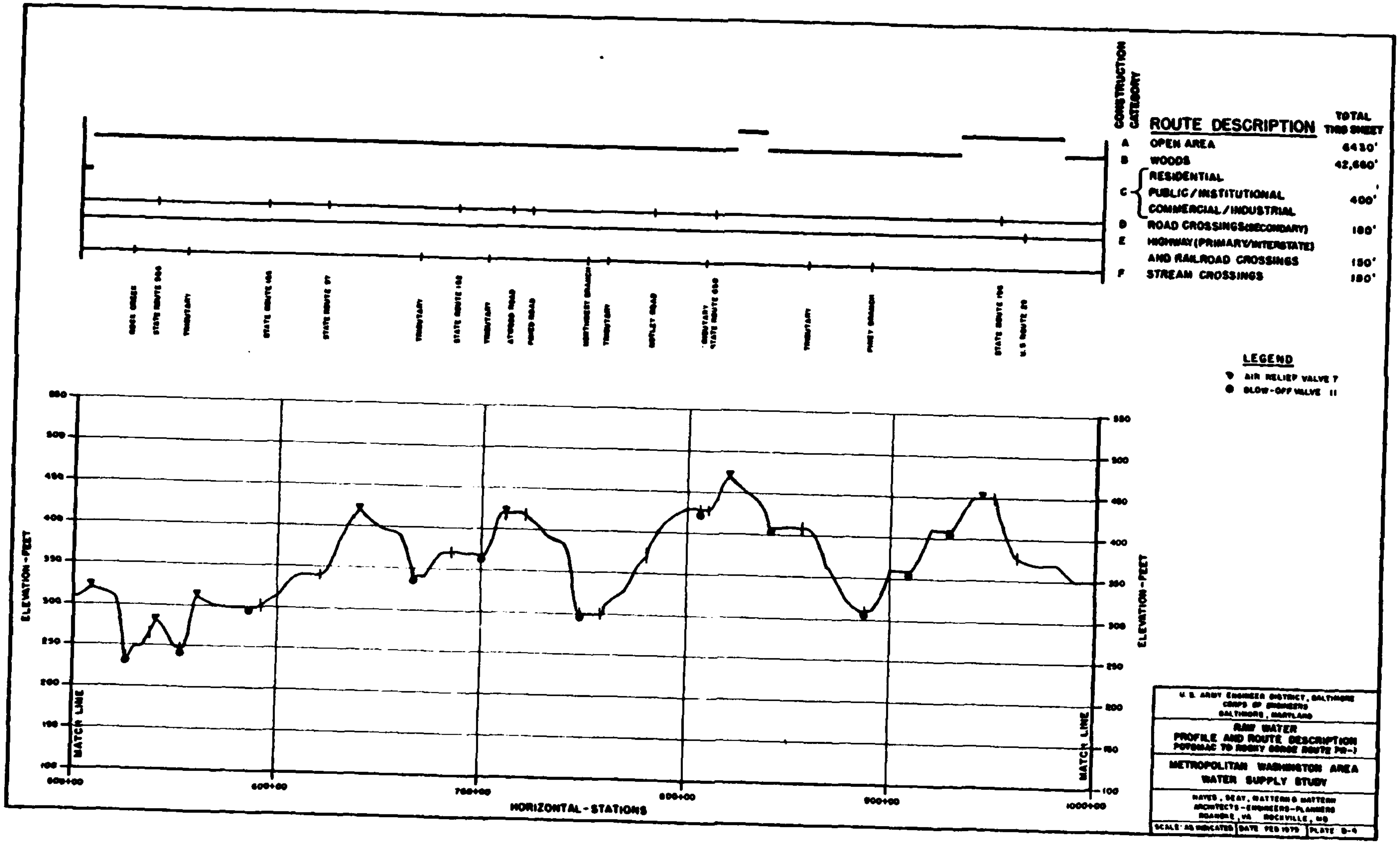

ROUTE DESCRIPTION
CONSTRUCTION CATEGORY
TOTAL THIS SHEET
A OPEN AREA 25,280'
B WOODS 2560'
C RESIDENTIAL
PUBLIC/INSTITUTIONAL 21,260'
COMMERCIAL/INDUSTRIAL
D ROAD CROSSINGS(SECONDARY) 320'
E HIGHWAY (PRIMARY/INTERSTATE) AND RAILROAD CROSSINGS 300'
F STREAM CROSSINGS 200'
LEGEND
AIR RELIEF VALVE
BLOW-OFF VALVE
POTOMAC PUMPING STATION PR NO. 1
MATCH LINE
ELEVATION-FEET
HORIZONTAL-STATIONS
RAW WATER
PROFILE AND ROUTE DESCRIPTION
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY

Figure E-9



CONSTRUCTION CATEGORY
ROUTE DESCRIPTION
TOTAL THIS SHEET
A OPEN AREA 6430'
B WOODS 42,660'
C RESIDENTIAL
PUBLIC/INSTITUTIONAL 400'
COMMERCIAL/INDUSTRIAL
D ROAD CROSSINGS(SECONDARY) 180'
E HIGHWAY(PRIMARY/INTERSTATE) AND RAILROAD CROSSINGS 150'
F STREAM CROSSINGS 180'
LEGEND
AIR RELIEF VALVE 7
BLOW-OFF VALVE 11
ELEVATION-FEET
HORIZONTAL-STATIONS
MATCH LINE
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND
RAW WATER
PROFILE AND ROUTE DESCRIPTION
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY

Figure E-10

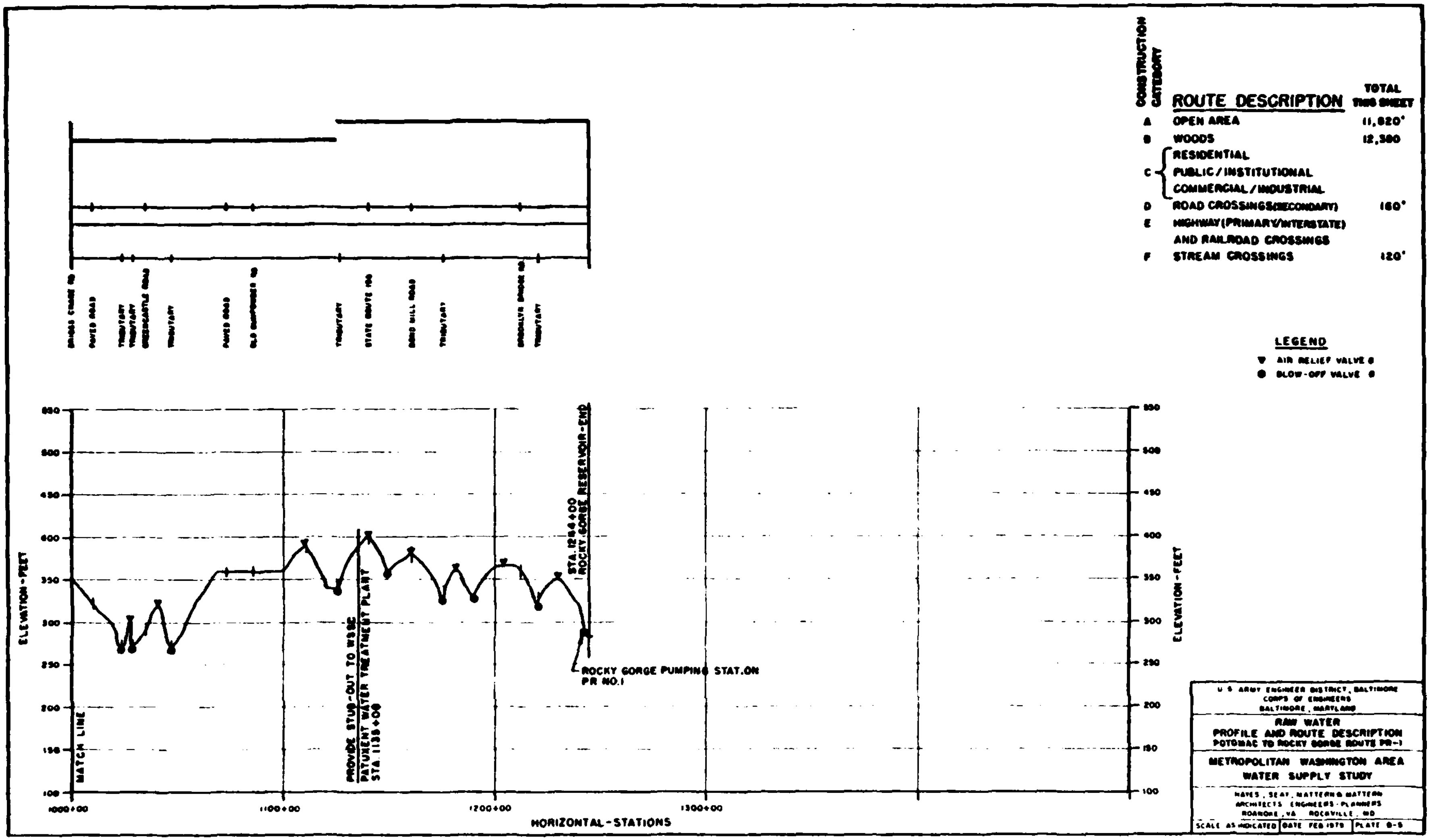

CONSTRUCTION CATEGORY
ROUTE DESCRIPTION
TOTAL THIS SHEET
A OPEN AREA 11,820'
B WOODS 12,380
C RESIDENTIAL
PUBLIC/INSTITUTIONAL
COMMERCIAL/INDUSTRIAL
D ROAD CROSSINGS(SECONDARY) 180'
E HIGHWAY(PRIMARY/INTERSTATE) AND RAILROAD CROSSINGS
F STREAM CROSSINGS 120'
LEGEND
AIR RELIEF VALVE
BLOW-OFF VALVE
ELEVATION-FEET
MATCH LINE
PROVIDE STUB-OUT TO WSSC
PATUXENT WATER TREATMENT PLANT
STA 1135+00
STA. 1284+00
ROCKY GORGE RESERVOIR-END
ROCKY GORGE PUMPING STATION
PR NO.1
1000+00
1100+00
1200+00
1300+00
HORIZONTAL-STATIONS
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND
RAW WATER
PROFILE AND ROUTE DESCRIPTION
POTOMAC TO ROCKY GORGE ROUTE PR-1
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY

Figure E-11

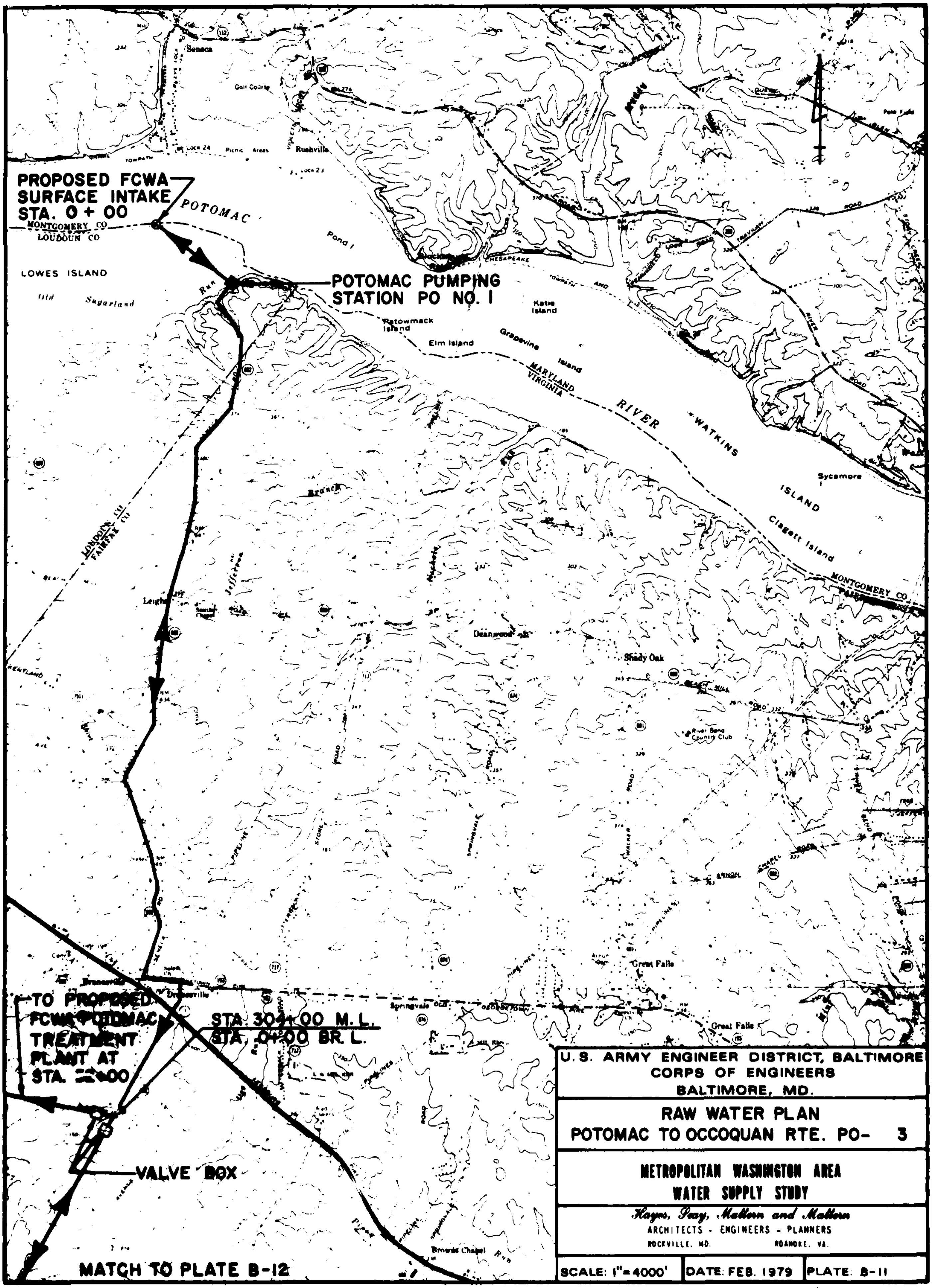

PROPOSED FCWA SURFACE INTAKE STA. 0 + 00
POTOMAC
MONTGOMERY CO
LOUDOUN CO
LOWES ISLAND
POTOMAC PUMPING STATION PO NO. I
Seneca
Rushville
Katie Island
Patowmack Island
Elm Island
Grapevine Island
MARYLAND
VIRGINIA
RIVER
WATKINS ISLAND
Sycamore
Clagett Island
MONTGOMERY CO
LOUDOUN CO
FAIRFAX CO
Shady Oak
River Bend Country Club
Great Falls
Dranesville
Springvale
TO PROPOSED FCWA POTOMAC TREATMENT PLANT AT STA. 22+00
STA. 304+00 M.L.
STA. 0+00 BR. L.
VALVE BOX
MATCH TO PLATE B-12
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MD.
RAW WATER PLAN
POTOMAC TO OCCOQUAN RTE. PO- 3
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
Hayes, Seay, Mattern and Mattern
ARCHITECTS - ENGINEERS - PLANNERS
ROCKVILLE, MD. ROANOKE, VA.
SCALE: 1"=4000'
DATE: FEB. 1979
PLATE: B-11

Figure E-12

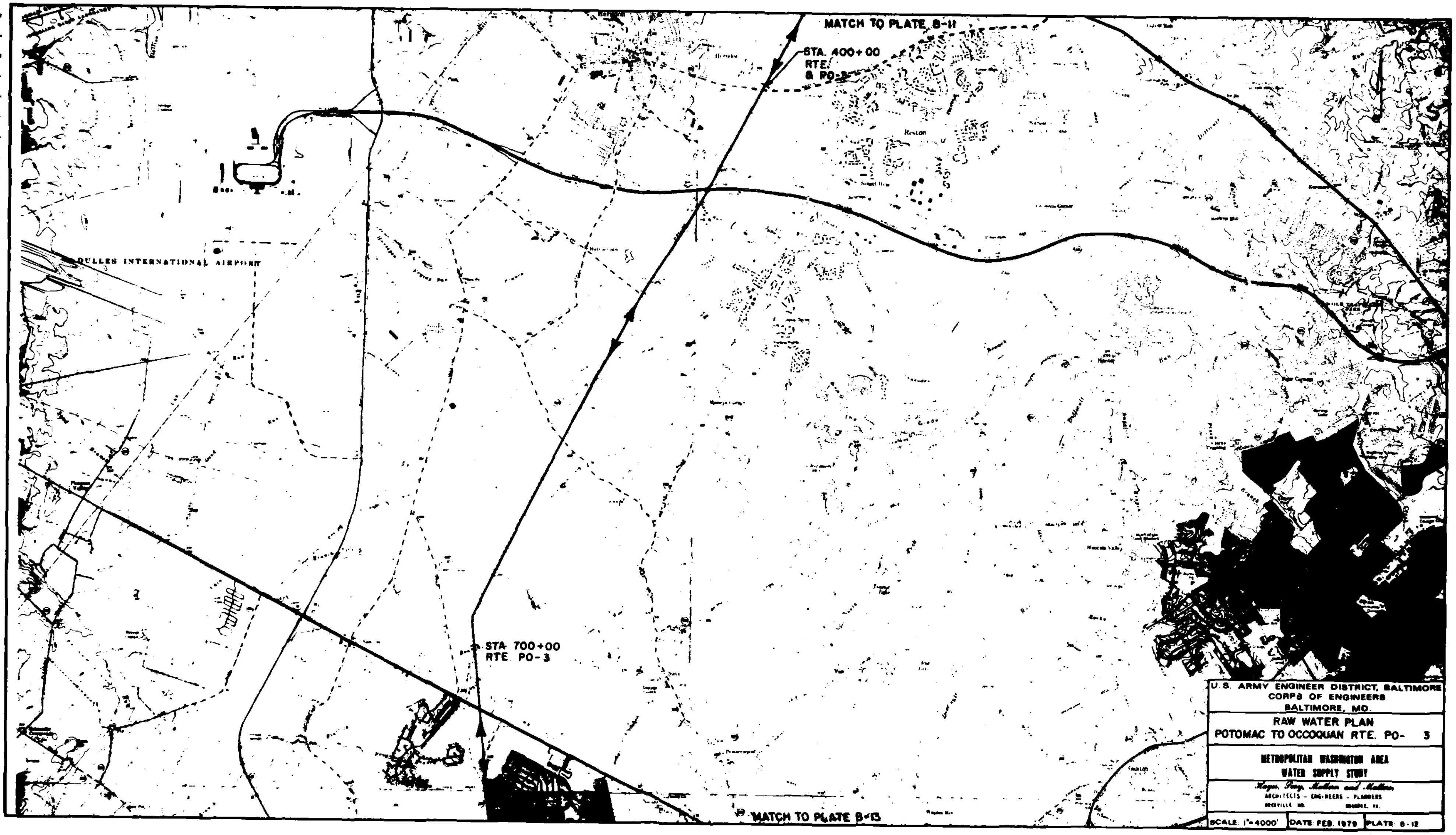

MATCH TO PLATE B-11
STA. 400+00
RTE.
& PO-3
DULLES INTERNATIONAL AIRPORT
Reston
STA 700+00
RTE PO-3
MATCH TO PLATE B-13
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MD.
RAW WATER PLAN
POTOMAC TO OCCOQUAN RTE. PO- 3
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
SCALE 1"=4000'
DATE FEB. 1979
PLATE B-12

Figure E-13

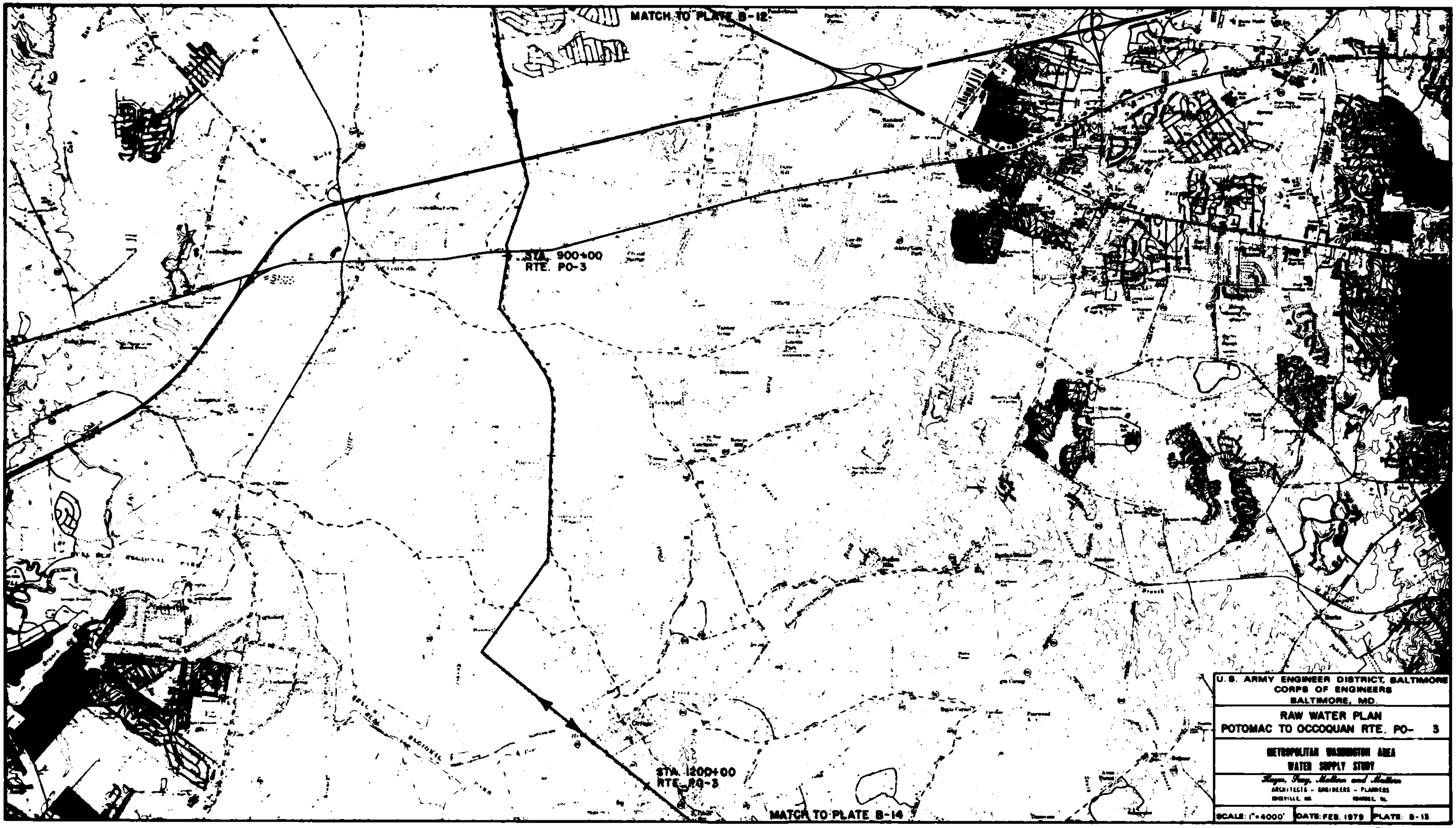

MATCH TO PLATE B-12
STA. 900+00
RTE. PO-3
STA. 1200+00
RTE. PO-3
MATCH TO PLATE B-14
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MD.
RAW WATER PLAN
POTOMAC TO OCCOQUAN RTE. PO- 3
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
ARCHITECTS - ENGINEERS - PLANNERS
SCALE: 1"=4000'
DATE: FEB. 1979
PLATE: B-13

Figure E-14

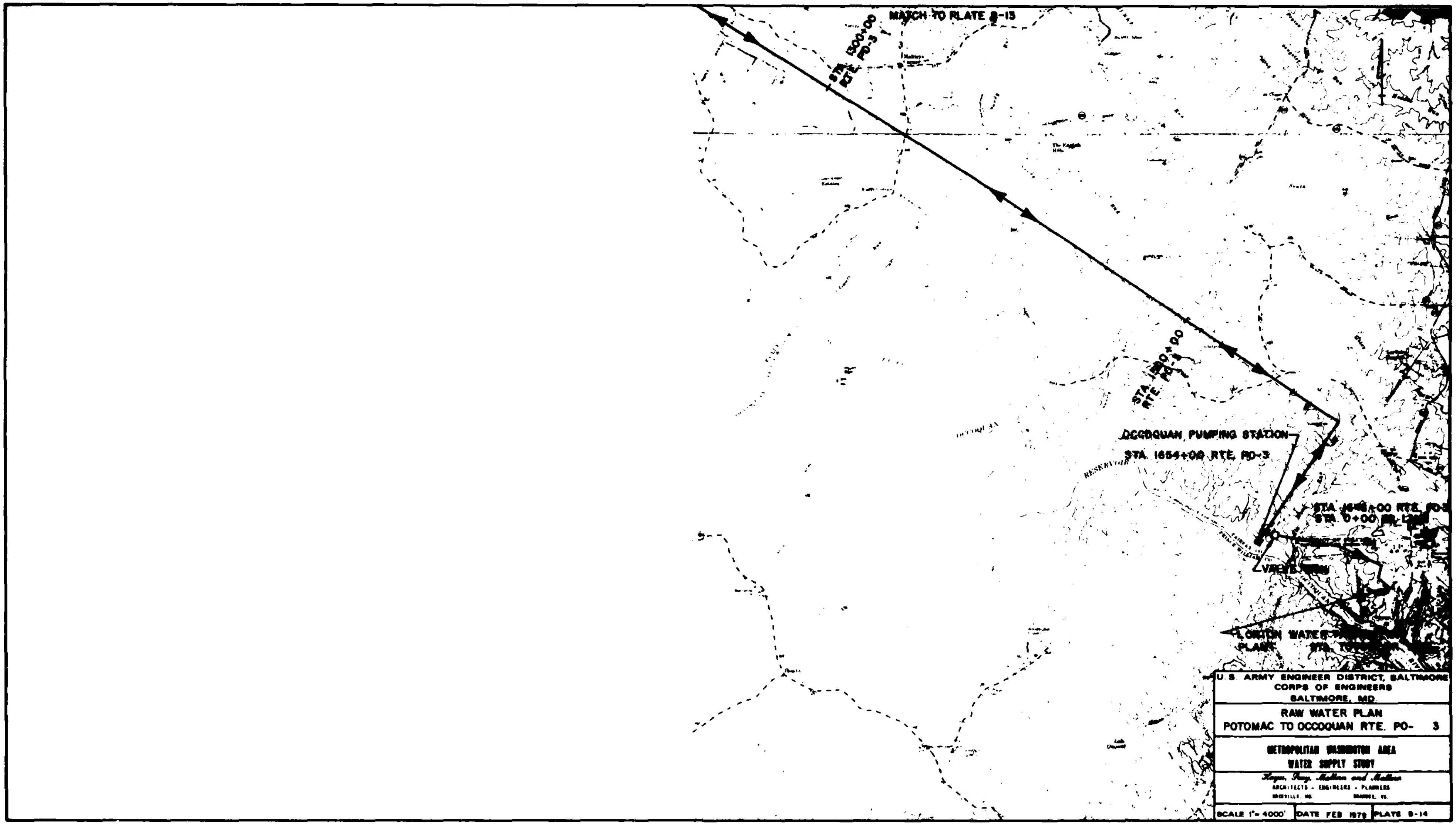

MATCH TO PLATE B-13
STA. 1500+00 RTE. PO-3
STA. 1590+00 RTE. PO-3
OCCOQUAN PUMPING STATION
STA. 1654+00 RTE. PO-3
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MD.
RAW WATER PLAN
POTOMAC TO OCCOQUAN RTE. PO- 3
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
SCALE 1"= 4000'
DATE FEB 1979
PLATE B-14

Figure E-15

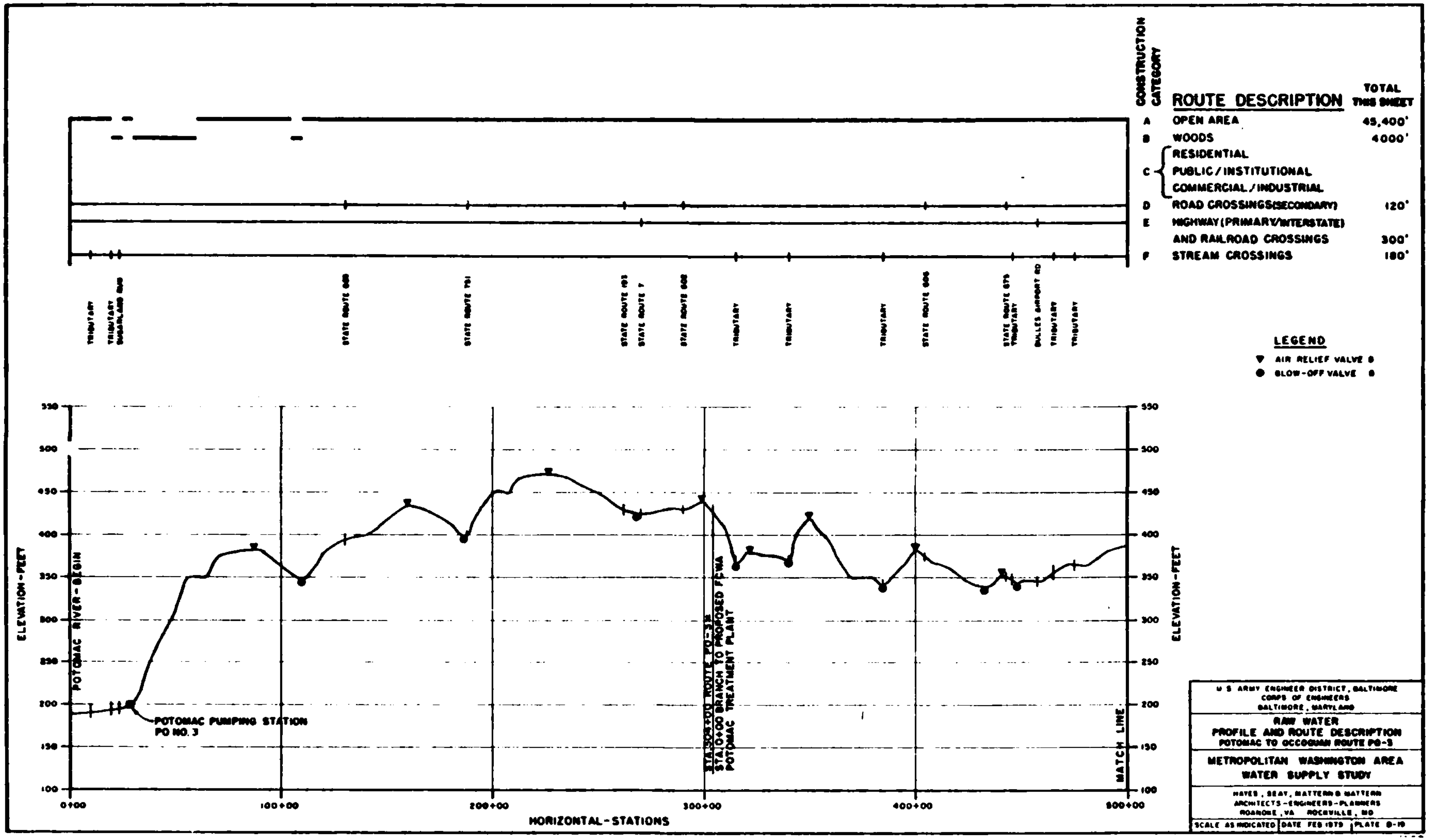


Figure E-16

E-44

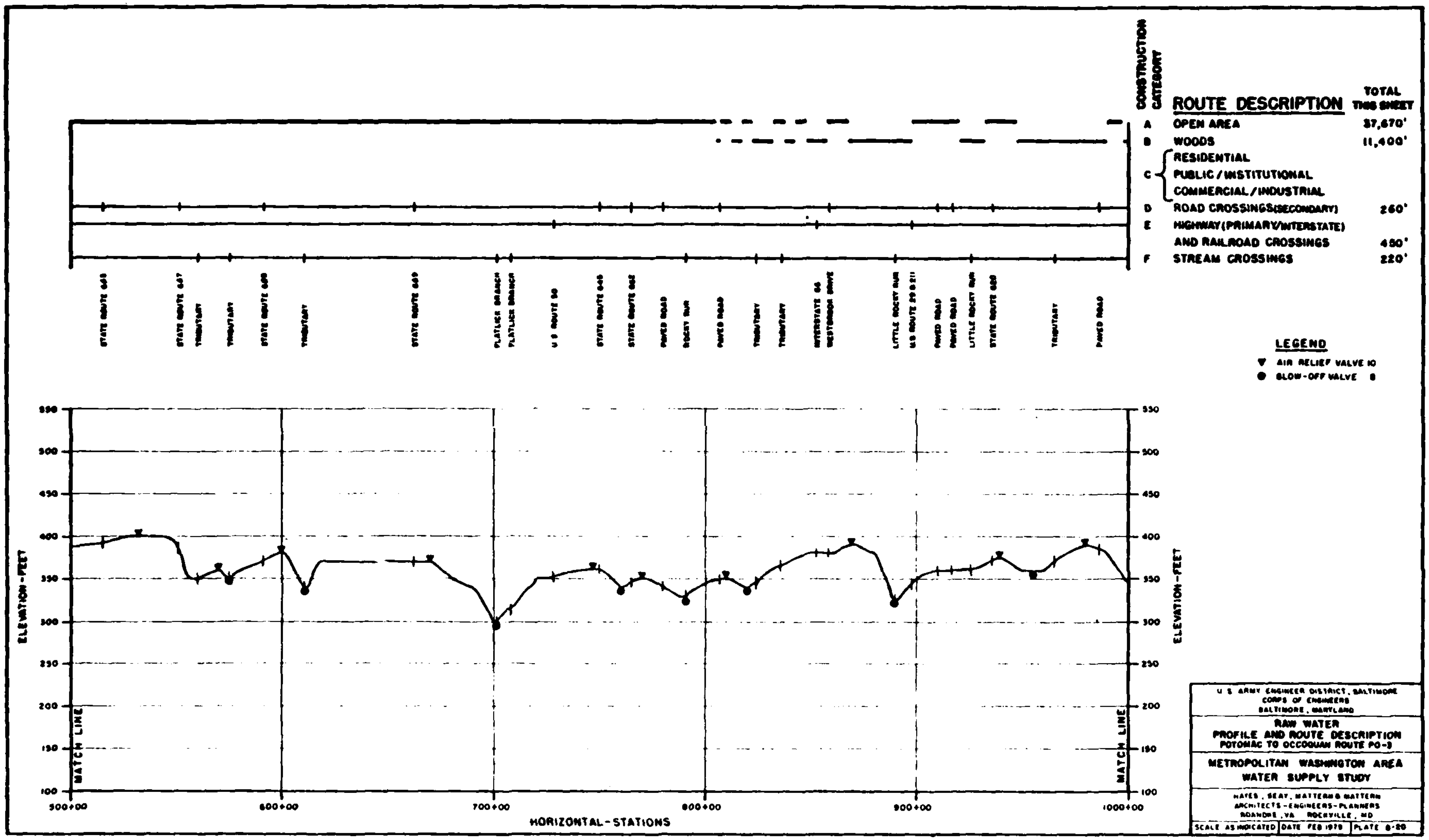

CONSTRUCTION CATEGORY
ROUTE DESCRIPTION
TOTAL THIS SHEET
A OPEN AREA 37,670'
B WOODS 11,400'
C RESIDENTIAL
PUBLIC / INSTITUTIONAL
COMMERCIAL / INDUSTRIAL
D ROAD CROSSINGS(SECONDARY) 260'
E HIGHWAY (PRIMARY/INTERSTATE)
AND RAILROAD CROSSINGS 450'
F STREAM CROSSINGS 220'
LEGEND
AIR RELIEF VALVE 10
BLOW-OFF VALVE 8
ELEVATION-FEET
HORIZONTAL-STATIONS
MATCH LINE
500+00
600+00
700+00
800+00
900+00
1000+00
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND
RAW WATER
PROFILE AND ROUTE DESCRIPTION
POTOMAC TO OCCOQUAN ROUTE PO-3
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
HAYES, SEAY, MATTERN & MATTERN
ARCHITECTS-ENGINEERS-PLANNERS
ROANOKE, VA ROCKVILLE, MD
SCALE AS INDICATED
DATE FEB 1979
PLATE B-20

Figure E-17

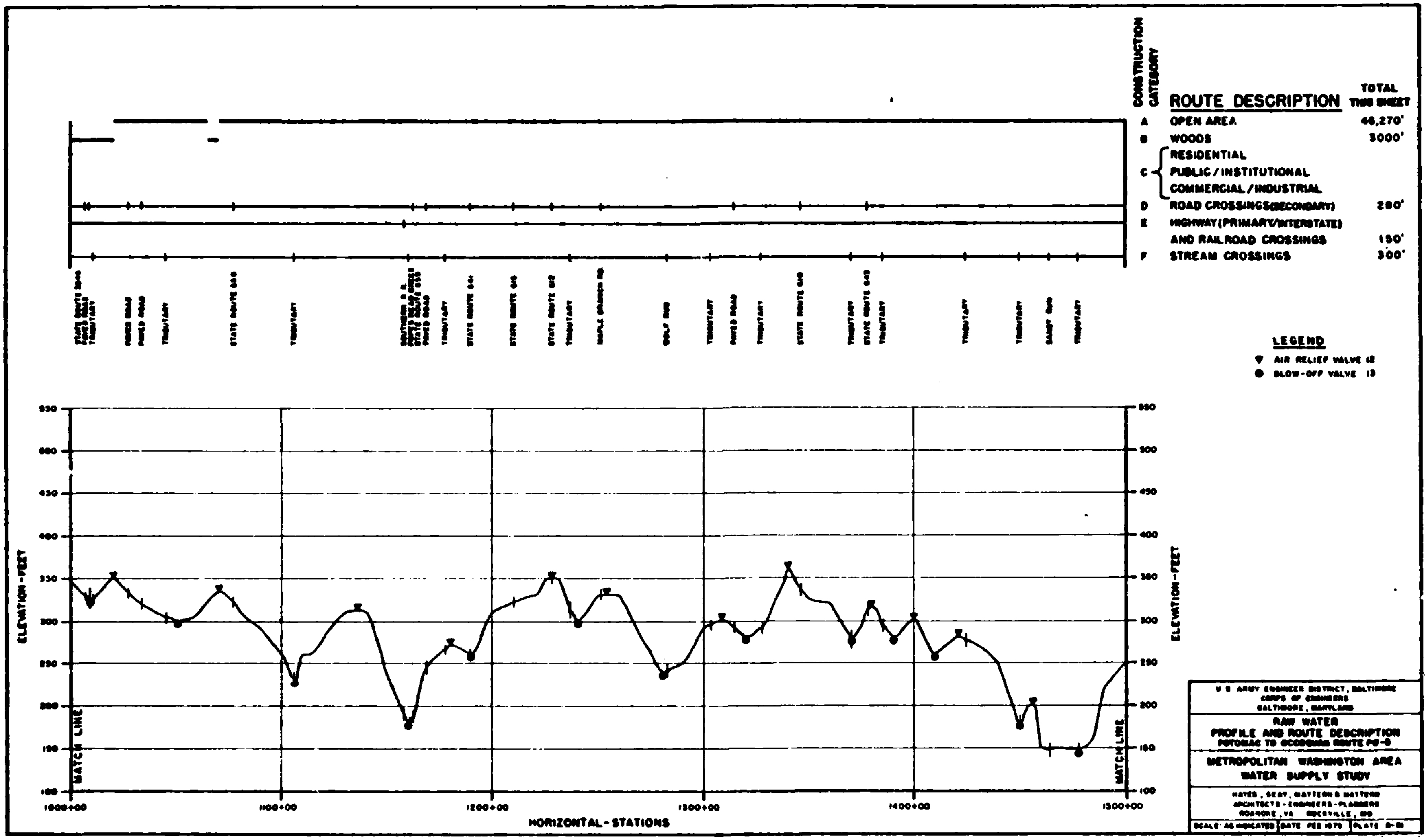

CONSTRUCTION CATEGORY
ROUTE DESCRIPTION
TOTAL THIS SHEET
A OPEN AREA 46,270'
B WOODS 3000'
C RESIDENTIAL
PUBLIC/INSTITUTIONAL
COMMERCIAL/INDUSTRIAL
D ROAD CROSSINGS(SECONDARY) 280'
E HIGHWAY(PRIMARY/INTERSTATE)
AND RAILROAD CROSSINGS 150'
F STREAM CROSSINGS 300'
LEGEND
AIR RELIEF VALVE 12
BLOW-OFF VALVE 13
ELEVATION-FEET
HORIZONTAL-STATIONS
MATCH LINE
U S ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND
RAW WATER
PROFILE AND ROUTE DESCRIPTION
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY

Figure E-18

AD-A134 157 METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY APPENDIX E RAW AND FINISH..(U) CORPS OF ENGINEERS BALTIMORE MD BALTIMORE DISTRICT SEP 83 MWA-83-P-APP-E

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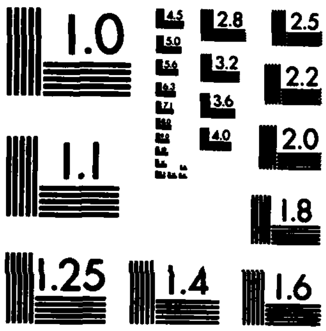
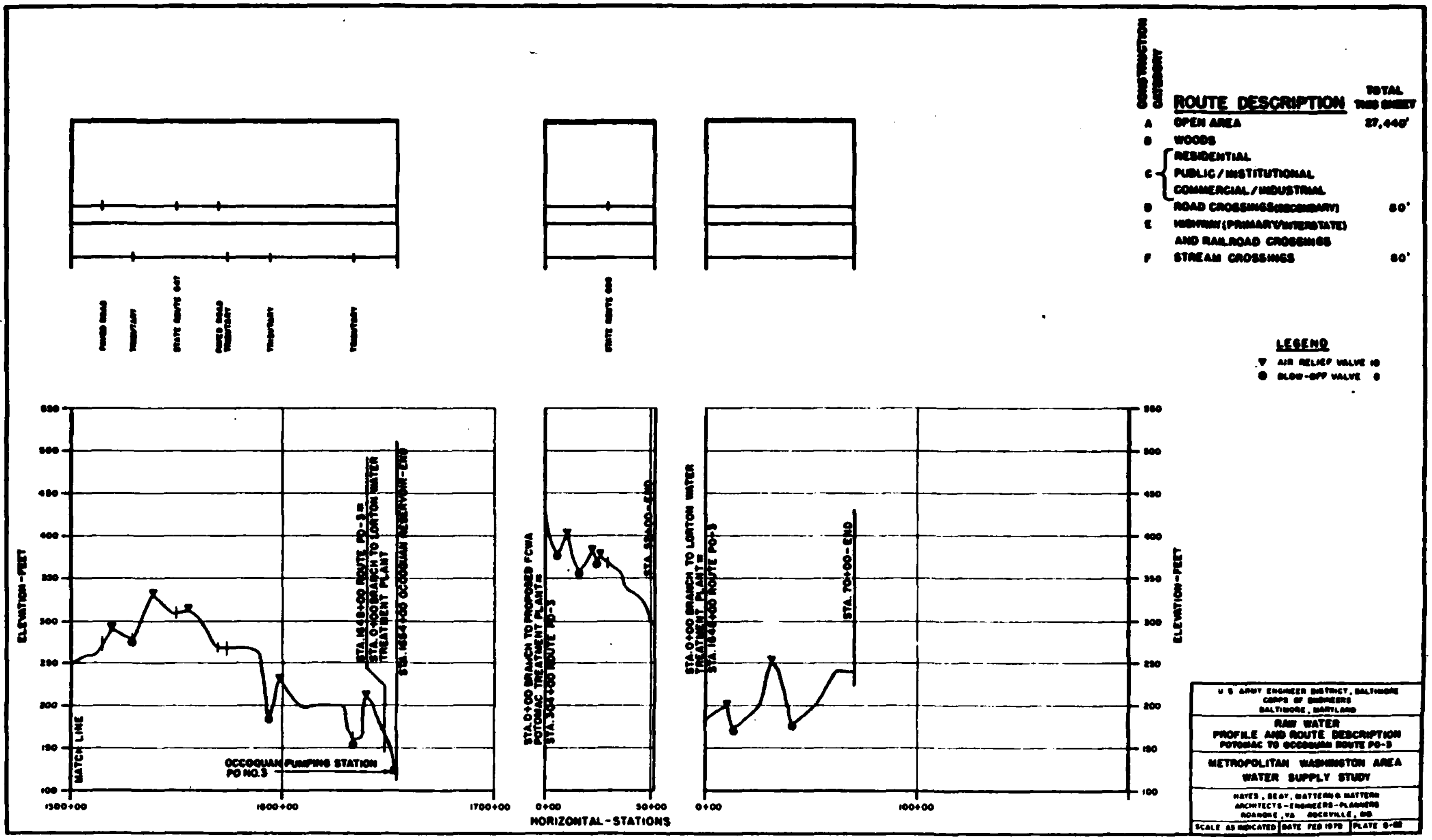


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



ROUTE DESCRIPTION
CONSTRUCTION CATEGORY
TOTAL THIS SHEET
A OPEN AREA 27,440'
B WOODS
C RESIDENTIAL
PUBLIC/INSTITUTIONAL
COMMERCIAL/INDUSTRIAL
D ROAD CROSSINGS(SECONDARY) 80'
E HIGHWAY(PRIMARY/INTERSTATE) AND RAILROAD CROSSINGS
F STREAM CROSSINGS 80'
LEGEND
AIR RELIEF VALVE 10
BLOW-OFF VALVE 8
ELEVATION-FEET
HORIZONTAL-STATIONS
MATCH LINE
OCCOQUAN PUMPING STATION PO NO.3
STA.1648+00 ROUTE PO-3= STA.0+00 BRANCH TO LORTON WATER TREATMENT PLANT
STA.1654+00 OCCOQUAN RESERVOIR-END
STA.0+00 BRANCH TO PROPOSED FCWA POTOMAC TREATMENT PLANT= STA.304+00 ROUTE PO-3
STA.30+00-END
STA.0+00 BRANCH TO LORTON WATER TREATMENT PLANT= STA.1648+00 ROUTE PO-3
STA.70+00-END
U S ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND
RAW WATER
PROFILE AND ROUTE DESCRIPTION
POTOMAC TO OCCOQUAN ROUTE PO-3
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
SCALE AS INDICATED
DATE FEB 1979

Figure E-19

FINISHED WATER INTERCONNECTIONS

GENERAL

Within the study limits of the Metropolitan Washington Area (MWA), there exists about 25 "independent" finished water supply systems. These systems are independent from the standpoint that their distribution systems are not interconnected, thereby prohibiting the transfer of large volumes of finished water between service areas in the event of an emergency (e.g., source contamination, plant failure, or drought). For the purposes of the MWA Water Supply Study, these 25 systems have been grouped into eight primary water service areas as follows:

A. Washington Aqueduct Division (WAD)

B. Washington Suburban Sanitary Commission (WSSC)

C. Fairfax County Water Authority (FCWA)

D. Rockville City

E. Fairfax City

F. Charles County

G. Loudoun County

H. Prince William County

The three largest suppliers in the MWA are the Aqueduct, WSSC, and FCWA, providing over 95 percent of the area's treated water. These three agencies obtain all or part of their raw water supply from the Potomac River.

It is the purpose of this section to examine one water supply component which could apply directly to these three major water service areas: finished water interconnections. This component was examined on the basis of engineering feasibility and environmental impacts. The following is a brief explanation of the concept associated with finished water interconnections.

A finished water interconnection between two adjacent distribution systems is shown in schematic form in Figure E-20. The two basic elements in this component are: (1) a set of indepentent finished water distribution systems served by at least two distinct water treatment plants; and (2) a pipeline connecting the two systems. The primary purpose of such a finished water interconnection is to avert local water shortages by linking together the presently independent water supply systems with a pipeline and a pumping station. If a drought or emergency (e.g., source contamination, power outage, pump failure, etc.) should occur in one distribution system, water could be made available from an adjacent distribution system via an interconnecting pipeline.

Presented in the remainder of this section is a description of the engineering and environmental analyses used to determine the final finished water interconnection routes, and conceptual engineering design criteria and project costs for each of the final routes.

REPRESENTATION OF FINISHED WATER INTERCONNECTION OPERATION

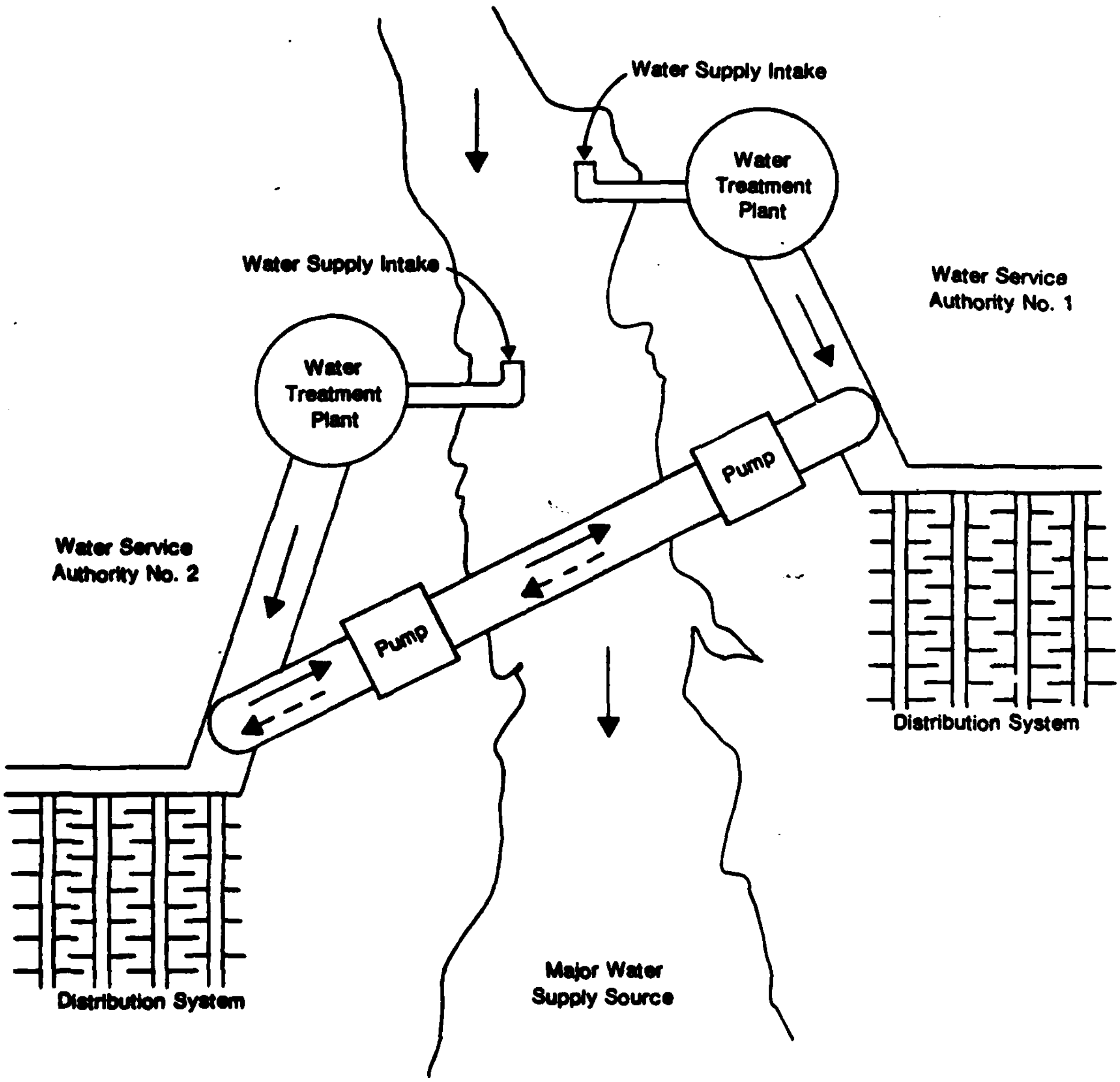


Figure E-20

ENGINEERING ANALYSIS

The primary purpose of using a finished water interconnection component is to avert local water shortages by interconnecting the presently independent water distribution systems by a pipeline assembly. In the evaluation of this component, three phases of analyses were performed. Phase One consisted of performing an engineering feasibility study which included evaluating previously proposed routes as well as generating additional finished water interconnection route possibilities. Phase Two consisted of examining the environmental impacts associated with those routes recommended for further consideration based on the engineering analysis performed in Phase One. Resulting from Phases One and Two was a set of finished water interconnection routes which, based on engineering and environmental considerations, were found to be the most feasible of all routes analyzed. Phase Three then consisted of taking these final routes and developing conceptual engineering designs and estimated project costs. This last phase was performed by the consulting engineering firm of Hayes, Seay, Mattern and Mattern under contract to the Corps of Engineers. The following sections describe the work performed in the development, evaluation, and design of the finished water interconnection routes.

PRELIMINARY IDENTIFICATION OF ROUTES

To identify potential finished water interconnection routes, research was done with existing reports that investigated water supply alternatives for the MWA, and an effort was made to identify those reports which recommended finished water interconnections as a feasible alternative. Only one report was identified that proposed to investigate regional finished water interconnections. This report was prepared by the consulting engineering firm of Black and Veatch in April 1974 for FCWA, WSSC, and the District of Columbia entitled Water Supply Study for Washington Metropolitan Area. Basically, this report identified five finished water transfer routes based primarily on preliminary engineering investigations and costs.

Table E-31 lists the routes proposed by Black and Veatch. Included in the table are the control points for each route (distribution system and/or treatment plant connected), direction of flow, route designation, and approximate length. Figure E-21, which is keyed to Table E-31, shows the approximate geographic locations of these routes.

MATHEMATICAL MODELING

The next phase of this evaluation involved analyzing the engineering feasibility of these interconnections. In order to perform the complex engineering techniques necessary to simulate and verify the area's three existing finished water distribution systems and to evaluate the hydraulic effects that an interconnection would produce on these systems, a computer model developed by Dr. Donald Woods of the University of Kentucky was utilized. This model, entitled Computer Program for the Analysis of Pressure and Flow in Pipe Distribution Systems determines under steady state conditions what the resulting pressures and flow velocities between two interconnected systems would be and if these values exceed the normal operating conditions of either system. For this particular study, the following input parameters were defined:

(1) The pipes in the system - this included major pipes over 12 inches (12-inch pipes were not included when they functioned as local or street mains), length and roughness, a parameter related to the age of the project.

TABLE E-31

FINISHED WATER INTERCONNECTION ROUTES PROPOSED BY BLACK AND VEATCH[1]

CONTROL POINTS				
DISTRIBUTION SYSTEM	TREATMENT PLANT	DIRECTION OF FLOW	ROUTE DESIGNATION	PROPOSED LENGTH (miles)
WSSC	WAD-Dalecarlia	Reversible	WAD-WSSC(#1)	2.7
WSSC-WAD[2]	—	Reversible	WAD-WSSC(#2)	3.6
WSSC	WAD-McMillan	Reversible	WAD-WSSC(#3)	5.5
Proposed FCWA Main	WAD-Dalecarlia	Reversible	WAD-FCWA(#4)	4.8
Proposed FCWA Main	WSSC-Potomac Plant	Reversible	WSSC-FCWA(#5)	5.0

[1] Source: Water Supply for the Washington Metropolitan Area by Black and Veatch, 1974

[2] Interconnection between two distribution systems.

GEOGRAPHIC LOCATIONS OF THE PROPOSED BLACK & VEATCH FINISHED WATER INTERCONNECTION ROUTES

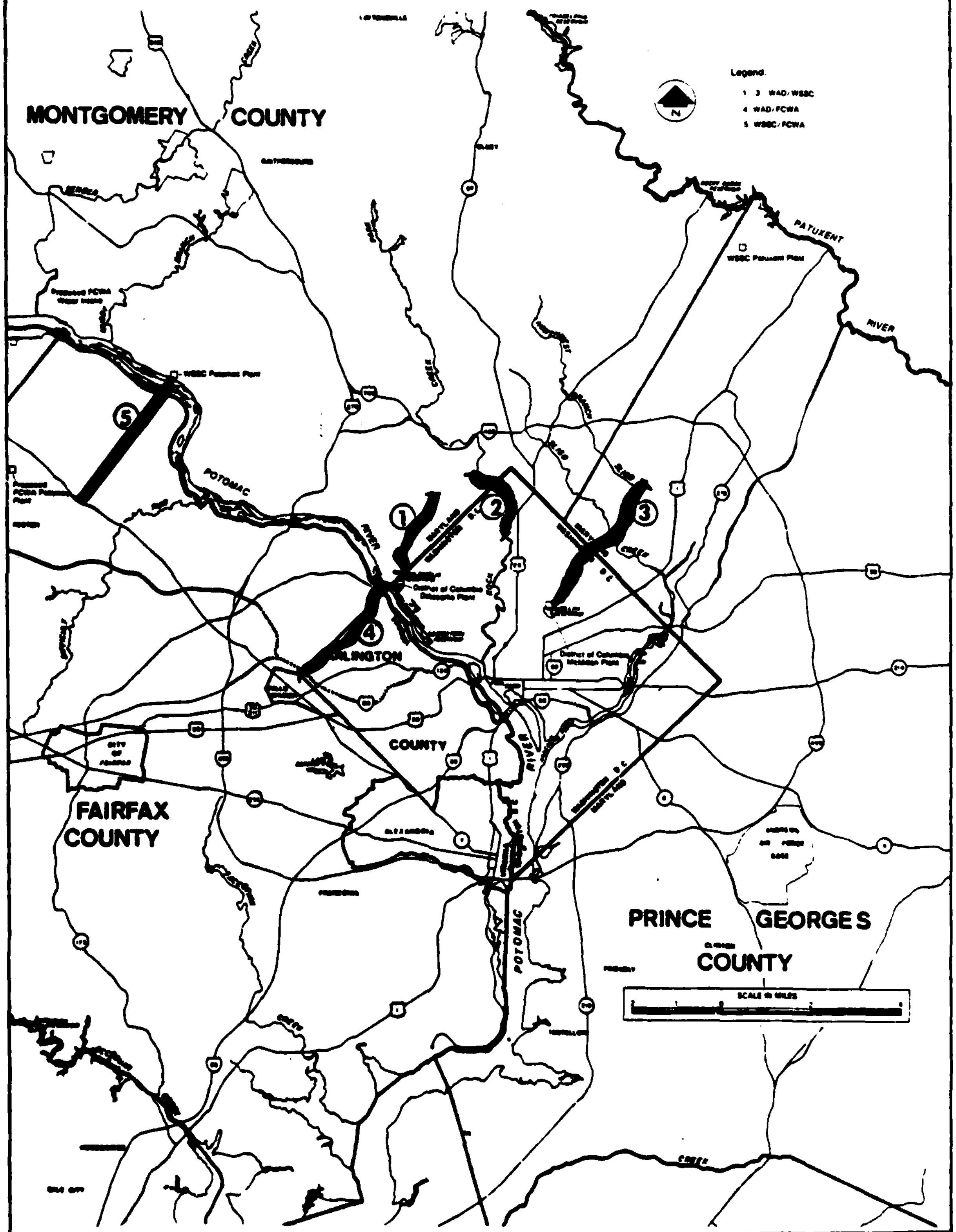


Figure E-21

(2) Pumps in the system - horsepower and design capacity.

(3) Ground level elevations at points where pressures are predicted.

(4) Water tank, tower, or standpipe locations.

(5) Locations and setting for pressure-regulating valves (pressure-reducing valves) in the system.

(6) Projected water demands throughout the system.

Given these data, the model then computed the pressures, flows, and velocities that would occur for each of the pipes in the distribution network. For the most part, the data used in the model were obtained from representatives of each of the water supply agencies addressed in this study (WSSC, WAD, and FCWA). Length and diameter data were determined from water supply system maps which were at a 1" to 2000' or larger scale. Where these maps were not clear, engineering drawings were consulted for important details such as the nature of connections between major pipes and the pipe configurations around the major pumping stations. Roughness measurements of the pipes were generally not available; therefore, the best judgements of the local water supply utility operators were used. Pressure-reducing valves, settings, and operating levels for storage tanks and reservoirs were also obtained from the appropriate water supply authorities along with pump capacities. Elevations for computing ground level pressures were obtained by overlaying water supply systems maps on United States Geological Survey 7.5 Minute Series Quadrangle Maps.

Despite the approximate nature of some of these data, in particular the roughness coefficients, model runs were made and the results indicated that the proposed interconnections performed well within the operational limitations of the existing system. In these model verification runs, the existing distribution networks were modeled using current water demands.

Pressures at pumping stations were adjusted to keep water storage tanks full and pipe velocities and system pressures were checked to ensure that they met with normal operating procedures. In general, the normal operating criteria met by the model were as follows:

(1) Pipe velocity will not exceed five feet per second (fps).

(2) Pipe pressures will not drop below 30 pounds per square inch (psi).

In all cases examined, it was possible to fill the storage tanks under an average demand condition.

Although verification of the model could not be considered "calibrated," it did indicate that the modeled system operated in such a manner as to be useful in examining the effect of new interconnections between adjacent water supply systems.

Water demands placed on each pipeline junction in the computer model were obtained by developing a per capita water use value for each water service area. Knowing the total service area demands and total populations, the resulting per capita values were

computed and assigned to each major pipeline junction. The population served at each pipeline junction was computed with the aid of the Metropolitan Washington Council of Governments (MWCOG) Transportation Planning Board Zones (TPBZ's).

In order to facilitate the numerous computations used by the computer model, individual water system models were developed. In total, 20 individual models were formulated. The following is a list of the main models developed and their distribution systems:

(1) WAD - Low Service, First High Service, Second High Service, Third High Service, Fourth High Service, Anacostia First High Service, and Anacostia Second High Service.

(2) WSSC - Montgomery Main Service, Montgomery High Service, Prince Georges Patuxent Service, Prince Georges Main Service, Prince Georges Intermediate Service, Prince Georges High Service, Prince Georges Potomac Service, and Piscataway Service.

(3) FCWA - Main Service and High Service.

(4) Arlington.

(5) Alexandria.

(6) Falls Church.

These individual models were integrated by connecting the systems at pumping stations and at pressure reducing valves (PRV). Discharges through the PRV's were modeled by determining the draw on the PRV of the downstream system and then adding that as additional demand to the appropriate node in the upstream system. Pumps were treated in much the same manner, with the exception that the flow and lift of the pumps were determined from the model with the required horsepower and checked against the available capacity.

Initially, the model was used to evaluate the five routes originally proposed by Black and Veatch (see Table E-22). During the course of the analysis, an additional three routes were identified and it was felt warranted to investigate these based on: (1) present water use patterns within the MWA; (2) conversations with representatives of the local water agencies; (3) individual knowledge of the areas' distribution system geometry; and (4) engineering judgement based on similar work experience. Listed below are the additional routes investigated:

(1) Route #6, D.C. Low Service and Anacostia First High Service - Prince Georges Potomac Service Finished Water Interconnection.

(2) Route #7, Arlington - Pentagon Emergency Service Finished Water Interconnection.

(3) Route #8, FCWA - Arlington County Interconnection.

Therefore, in the final analysis, eight finished water interconnection routes were examined.

CONSTRUCTION COST METHODOLOGY

As part of the engineering analysis, preliminary project costs were also computed for each of the eight routes analyzed. The following paragraphs briefly describe the procedure used to compute preliminary project costs for each finished water interconnection.

The data used to assign preliminary capital costs to the interconnections was obtained from information developed by the Fairfax County Water Authority. These data are comparable to WSSC procedures for computing cost estimates.

The cost criteria was divided into the three following categories: pump stations; pipeline and installation; and repaving and seal capping. The cost data collected for this appendix were based on an Engineering News Record (ENR) Index of 2000 (1974 price level). These data were then adjusted to an ENR of 3670 to reflect October 1981 price levels. The assumptions used in the cost analysis were:

(1) Whenever a pipeline route followed a roadway, repaving costs were computed.

(2) When pipeline routes went through parkland, regrading and restoration costs were estimated in the same manner as repaving costs.

(3) Repaving and regrading costs were estimated based on $15 a square yard assuming a two-foot width. This was added to the costs of the seal cap estimate based on $5 a square yard, allowing for a 30 foot wide trench.

Table E-32 shows the estimated costs per foot of pipeline by pipe diameter. These costs were obtained from the Fairfax County Water Authority and were based on typical costs for long pipelines. Table E-33 gives estimated construction costs for finished water pumping stations. Figure E-22 gives treatment plant costs in millions of dollars.

ASSESSMENT OF PROPOSED ROUTES

The purpose of this section is to present the results obtained from the computer model simulation (i.e., the rate of flow that can be expected to pass through the interconnected systems) performed for each of the pipeline routes analyzed. Also included is a breakdown of the preliminary costs attributed to the construction of each pipeline. All costs represent 1981 dollar values. Initially, the five routes proposed by Black and Veatch are presented, followed by the three additional routes identified.

Route #1: Dalecarlia (WAD) - Montgomery Main Service (WSSC) Finished Water Interconnection

This proposed reversible finished water interconnection would provide significant cost savings and improvement of the reliability of both the WAD and WSSC system. Additionally, it would provide the opportunity to reduce the environmental impacts of increased water withdrawals on the free-flowing Potomac River. A further discussion of the advantages of this interconnection can be found in a paper entitled More Water for Less Cost in the MWA, published in April 1978 by Dr. Daniel Sheer and Paul W. Eastman of the Interstate Commission on the Potomac River Basin (ICPRB).

TABLE E-32

PRELIMINARY PIPELINE UNIT COSTS
(October 1981 Prices)

PIPE DIAMETER (inches)	$/L.F.
8	22
10	28
12	31
16	40
18	46
20	51
24	64
30	92
36	123
42	150
48	180
54	60
60	239
66	284
72	330
78	385
84	440
90	495
96	550

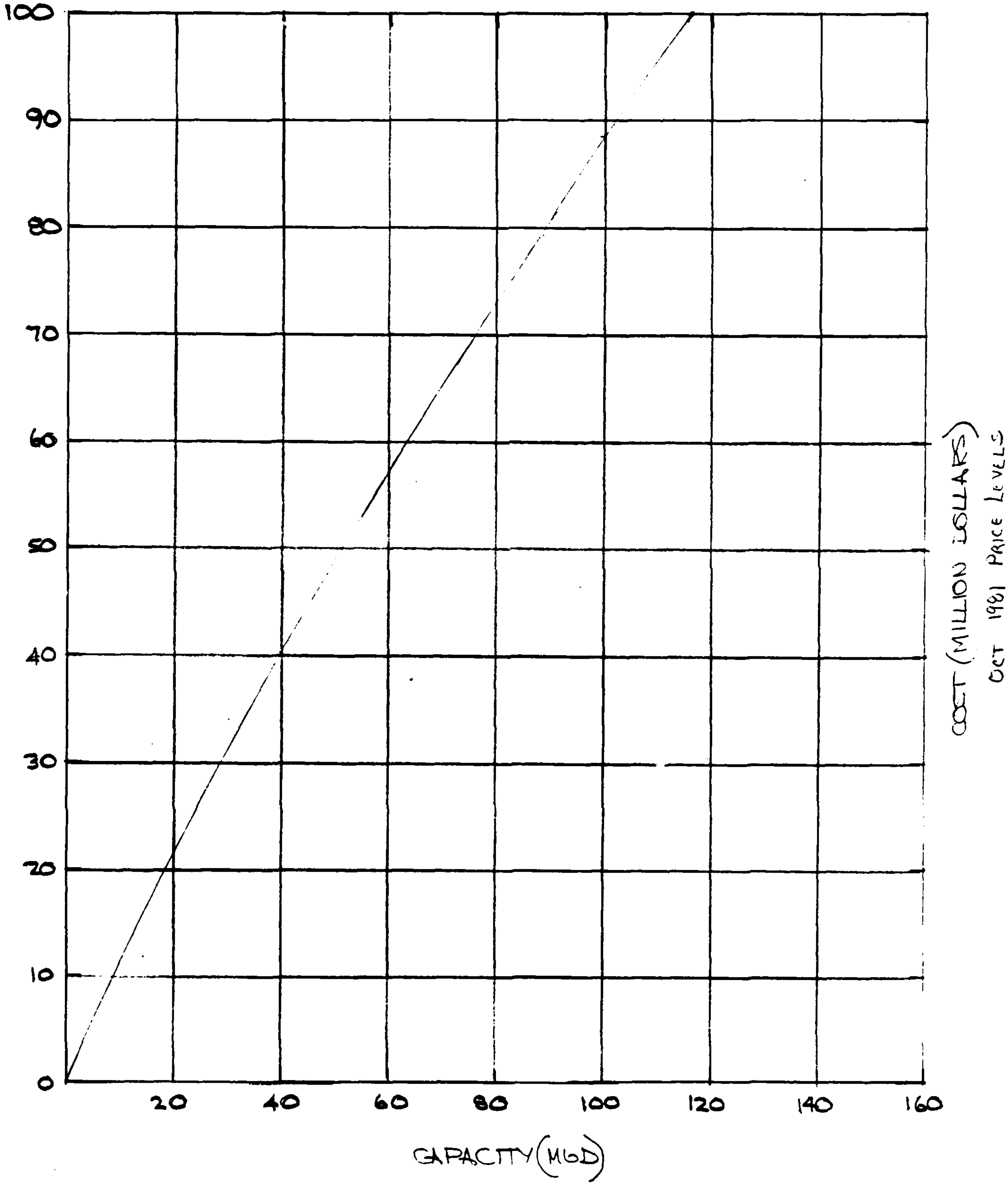
TABLE E-33

PRELIMINARY PUMPING STATION COSTS
($1,000 - October 1981 Prices)

Firm Capacity (MGD)	Structure Cost	Equipment Cost	Total Cost
4	$95	$205	$300
6	140	370	510
8	170	460	630
10	230	550	780
20	410	880	1,290
30	505	1,060	1,565
40	660	1,375	2,035
60	860	1,705	2,565
80	1,090	2,030	3,120
100	1,470	2,360	3,830

FIGURE E-22

TREATMENT PLANT COSTS



To insure the feasibility of this interconnection, a computer analysis of the Montgomery Main Service of the WSSC was made. The results showed excellent system operation with the finished water interconnection in place, assuming an inflow of 60 mgd to the system at the point of interconnection. Because of its proximity to the major demands in the Bethesda area, this was considered an excellent point at which to introduce a new source of supply for the WSSC system.

The total preliminary construction cost of this finished water interconnection was estimated to be about 7.4 million dollars, as detailed in Table E-34. The cost savings to be realized by the construction of this finished water interconnection arise from the availability of potential surplus treatment capacity in the WAD system; as much as 100 mgd of surplus capacity may be available. If not utilized by this or some other finished water interconnection which expands the WAD water service area, this capacity will be unused until sometime in the future. At this time, the cost for activating the surplus filtration capcity is unknown, but it was assumed for this analysis to be about three million dollars for a 60 mgd capacity. This three million dollar cost can be compared to the cost of constructing a new 60 mgd capacity plant for WSSC. This cost, taken from the cost treatment plant curve in Figure E-22, would be between 50 and 60 million dollars.

The reliability benefits attributable to this interconnection arise from the fact that in the case of failure of the WSSC Potomac treatment plant, an additional 60 mgd of treatment capacity would be available to the WSSC system. Had this interconnection been in place during the summer of 1977, many of the problems associated with the Potomac treatment plant fire could have been avoided. Additionally, should a failure occur at Dalecarlia, the flow in the finished water interconnection could be reversed and flow by gravity to the Dalecarlia pumping station. Based on cost and the increased reliability afforded by this interconnection, this route was retained for analysis with regard to environmental considerations.

It is important to note that the costs presented in Tables E-34 through E-40 were preliminary estimates only. Later work, as described beginning on page E-113, was performed to develop more detailed design and cost information.

TABLE E-34

PRELIMINARY COST OF DALECARLIA-MONTGOMERY MAIN SERVICE
FINISHED WATER INTERCONNECTION ROUTE #1
(October 1981 Price Level)

Pump Station	
60 mgd	$2.6 million
Pipeline and Installation 16,000 ft. of 60 in. pipe @ $239/foot	3.8 million
Regrading, Repaving, and Restoration 16,000 ft. @ $60/foot	1.0 million
TOTAL COST	$7.4 million

Route #2: D.C. Third High (WAD) - Montgomery Main Service (WSSC) Finished Water Interconnection

This proposed reversible interconnection consists of a 54" pipeline running up Rock Creek from the 48" D.C. Third High Service line at Military Road to the WSSC 54" line at East West Highway in Bethesda. The benefits attributable to this interconnection are similar to, but smaller than those associated with Route #1 WAD-Montgomery Main Service finished water interconnection. The benefits would be smaller for two reasons: first the interconnection would have a smaller capacity, 37 mgd as opposed to 60 mgd; and second, a portion of the water transferred to the WSSC system would have to come via the Bryant Street Pumping Station. The Bryant Street station, which pumps water from the McMillan treatment plant, is limited to an average capacity of 135 mgd by the size of the raw water transmission tunnel between Georgetown and the McMillan Reservoir. Additionally, because of the station's convenient location in the center of the District of Columbia, it is desirable to supply much of the District from McMillan rather than from Dalecarlia. Shorter transmission distance means lower pumping costs. Pumping water from the Bryant Street Pumping Station to the WSSC system would increase the area which could not be served by water from the McMillan Reservoir.

These disadvantages made Route #2 (the D.C. Third High - WSSC Montgomery Main) finished water interconnection less desirable than the WAD - Montgomery Main interconnection. One advantage, however, of this interconnection over Route #1 is that it would make possible the transmission of treated water directly to the McMillan Treatment Plant in the event of a failure at McMillan. The cost of Route #2 is estimated to be 6.5 million dollars (see Table E-35).

TABLE E-35

PRELIMINARY COST OF D.C. THIRD HIGH-MONTGOMERY MAIN FINISHED WATER INTERCONNECTION ROUTE #2
(October 1981 Prices)

Pipeline and Installation	
17,000 ft. of 54 inch pipe @ 211/foot	$3.6 million
Regrading, Repaving, and Restoration	
17,000 ft. @ $60/foot	1.0 million
Pump Station	
37 mgd	1.9 million
TOTAL COST	$6.5 million

Route #3: Bryant Street Pumping Station - Prince Georges Main Service Finished Water Interconnection

This proposed 60" reversible finished water interconnection travels between the Bryant Street Pumping Station and WSSC Prince Georges Main Service and includes a pumping station capable of transmitting some 60 mgd of WAD water to the WSSC in times of emergency. In the event of a failure at McMillan, the WSSC could provide water to the District by gravity.

Under normal operation, this interconnection would pump water from the McMillan treatment plant rather than from Dalecarlia, the disadvantages of which were discussed previously under Route #2. In emergency operation, the interconnection could not supply water to the Montgomery Main system, leaving a substantial portion of the WSSC system without protection from failure of the WSSC Potomac Treatment plant. The estimated preliminary cost of this interconnection is 12.5 million dollars, as shown in Table E-36.

The single advantage this interconnection has is in the area of reliability for the District of Columbia sub-systems. For example, in the event of a failure at McMillan, water could be provided without pumping from the Bryant Street Pumping Station. However, this advantage is outweighed by the disadvantages of the interconnection, and therefore this route was dropped from any further analysis.

TABLE E-36

PRELIMINARY COST OF BRYANT STREET PUMPING STATION - PRINCE GEORGES MAIN SERVICE INTERCONNECTION ROUTE #3
(October 1981 Prices)

Pipeline and Installation	
33,000 ft. of 60 inch @ $239/foot	$7.9 million
Regrading, Repaving, Restoration, and Seal Cap	
33,000 ft. @ $60/foot	2.0 million
Pump Station	
60 mgd	2.6 million
TOTAL COST	12.5 million

Route #4: FCWA-WAD Finished Water Interconnection

Initially, a reversible finished water interconnection between the WAD and the FCWA was considered to replace the proposed FCWA Potomac treatment plant as a source of Potomac water for the FCWA water service area. This interconnection would provide the same environmental and cost benefits as Route #1, the WAD Montgomery Main Service finished water interconnection, discussed earlier. The costs and benefits are smaller, however, because of the increased length of pipe necessary to convey water from the Dalecarlia treatment plant to the FCWA proposed distribution system.

Reliability benefits due to this finished water interconnection are also smaller than for the WAD-Montgomery Main finished water interconnection. This is due to the much smaller size of the FCWA water service system. However, in an emergency at the WAD system, the FCWA would be able to supply less water back to the WAD through the interconnection than the WSSC because of its smaller treatment capacity. For this reason, the pipeline was changed to operate only one-way from the WAD Dalecarlia plant to the FCWA system. Additionally, the route configuration proposed by Black and Veatch terminated far short of a possible distribution hookup as modeled for the FCWA system. Therefore, the proposed route alignment was modified to follow the route proposed by Black and Veatch and then run along Interstate Route 66 to the junction with the Capital Beltway where it would join the FCWA system. The estimated preliminary capital cost for the new route is more than 14 million dollars, as shown in Table E-37. The cost of 40 mgd treatment capacity which would not have to be constructed at the Potomac treatment plant by the FCWA was computed at between 30 and 40 million dollars.

TABLE E-37

PRELIMINARY COST OF FCWA-WAD
FINISHED WATER INTERCONNECTION ROUTE #4
(October 1981 Price Level)

Pump Station	
40 mgd	$2.0 million
Pipeline and Installation	
40,000 ft. of 48 inch pipe @ $180/foot	7.2 million
Repaving and Seal Cap	
37,000 ft. @ $60/foot	2.2 million
Potomac River Crossing	3.4 million
TOTAL COST	14.8 million

Route #5: WSSC - FCWA Finished Water Interconnection

This proposed interconnection was designed to provide reliable benefits to the WSSC and the FCWA water service systems in the event of failure at either of their Potomac treatment plants by providing the capability for water transfers during emergency situations. Since there is no surplus treatment capacity in either the FCWA or the WSSC systems, no cost savings were possible with this interconnection.

Route #6: WAD-WSSC D.C. Low Service and Anacostia First High Service - Prince Georges (P.G.) Potomac Service Finished Water Interconnections

This proposed interconnection involves constructing a new interconnection operated in conjunction with an existing interconnection. The new one-way interconnection consists

of a 24" line leaving the D.C. Low Service system in the vicinity of Blue Plains and terminating at the P.G. Potomac system at the Forest Heights Elevated Tank. The existing interconnection also connects the D.C. Low Service and the P.G. Potomac Service systems, just north of the proposed route.

WSSC Prince Georges Potomac Service Area is almost 45 miles of pipeline from the primary source of water, the WSSC Potomac Treatment Plant. Presently, water served to this service area is pumped uphill a total of 485 feet. Water which would be delivered through the proposed interconnection would require only 126 foot of lift, saving almost 75 percent of the present energy cost. In addition, this finished water interconnection would supply approximately 14 mgd of water on a dependable basis, reducing the need for additional WSSC capital cost for treatment capacity by about eleven million dollars (assuming the water is available from WAD). The cost of the finished water interconnection is approximately 2.1 million dollars, including the necessary pumps, as shown in Table E-38.

TABLE E-38

PRELIMINARY COST OF D.C. LOW-ANACOSTIA FIRST HIGH SERVICE
PRINCE GEORGES POTOMAC SERVICE FINISHED WATER INTERCONNECTION
ROUTE #6
(October 1981 Prices)

Low Service - P.G. Potomac	
Pump Station	
10 mgd	.8 million
Pipeline and Installation	
9,000 ft. of 24 inch pipe @ $64/foot	.6 million
Repaving and Seal Cap	
7,700 ft. @ $50/foot	.4 million
Anacostia First High-P.G. Potomac	
Pump Station	
4 mgd	.3 million
TOTAL COST	2.1 million

Route #7: WAD-WAD Arlington-Pentagon Emergency Service Finished Water Interconnection

Arlington County obtains its finished water supply from WAD, through two separate pipeline river crossings near Chain Bridge. The Pentagon and National Airport both

depend upon receiving their water from two pipelines which cross at Key Bridge. A reversible finished water interconnection between these pipelines could be useful in emergency situations. Presently, three 12" interconnections exist between the Arlington and Pentagon systems. During short term emergencies Arlington could supply the Pentagon system with about 4-5 mgd through this interconnection. Two 24" lines cross at Eads and 12th Streets; however these lines are not presently connected. Arlington County Department of Public Works has indicated that any interconnection made at this point would not be useful to the county based on the current water supply available through existing interconnections and the age and condition of the Pentagon line. There is, however, a pressing need for Interconnection #7 to strenghten and increase the reliability of the Federally owned water main system serving the Pentagon and the Washington National Airport.

Route #8: FCWA - Arlington County Finished Water Interconnection

This proposed line consists of a 20-inch main that runs the length of the southwest border of Arlington County at a point just across the county boundary from Bailey's Crossroads. There is a pressure reducing valve (PRV) in a vault on that line. The PRV in this vault is kept closed, but links the Minor Hill Reservoirs to the Second Gravity system. The gradient on either side of the PRV is nominally 450 feet and 300 feet, whereas at the junction of two FCWA mains (one 16 inches and one 24 inches just east of Bailey's Crossroads), 420 feet is nominal. This interconnection would require just over 9,000 feet of 36 inch pipe to join the junction, and the PRV vault. Because of the pressure differential on either side of the vault, appropriate valving would be required to route the flow through this proposed interconnection without the need for additional pumping facilities. Theoretically, six to eight mgd could flow through this interconnection in either direction, but recent conversations with Arlington County indicate that field tests of the point show that only 2.5 mgd could be supplied to FCWA.

The interconnection could be used in three ways. First, it could provide a small amount of peaking capacity to Arlington County. Second, during off peak months, the interconnection could be used to reduce the drawdown of the Occoquan. If the interconnection were operated at five mgd, during the September through February period of the 1930-1931 drought, reservoir levels would have been increased by 750 million gallons. Third, the interconnection could be operated as an emergency interconnection. Its cost is about 1.4 million dollars, as shown in Table E-39.

TABLE E-39

PRELIMINARY COST OF FCWA-ARLINGTON COUNTY
FINISHED WATER INTERCONNECTION ROUTE #8
(October 1981 Prices)

Pipeline and Installation	
9,000 ft. of 36 inch pipe @ $118/foot	$1.1 million
Road Repaving and Seal Cap	
6,000 ft. @ $55/foot	.3 million
TOTAL COST	$1.4 million

CONCLUSIONS

Based on engineering feasibility and preliminary project cost considerations, five of the original eight finished water interconnection routes were determined to be viable and practicable alternatives. These interconnections were recommended for Phase Two: evaluation of environmental impacts. The five routes retained were composed of two from the Black and Veatch report and the three identified during the study. Listed below are the five routes:

a. WAD -WSSC

(1) Dalecarlia - Montgomery Main Service (Route #1).

(2) D.C. Low and Anacostia First High - Prince Georges Potomac Service (Route #6).

b. FCWA - WAD

(3) Fairfax County Water Authority - Arlington County (Route #8).

(4) Fairfax County Water Authority - Washington Aqueduct (Route #4).

c. WAD - WAD

(5) Arlington - Pentagon Emergency Service (Route #7).

Figure E-23 presents the geographic location of the final five finished water routes.

Table E-40 presents summary information on the hydraulic data and capital costs by category for each of the above selected finished water interconnection.

ENVIRONMENTAL ANALYSIS

REALIGNMENT

Prior to initiating the environmental impact analysis for the final five routes, a reevaluation of each route alignment was made. This work effort consisted of performing field surveys of the proposed alignments and the surrounding area. As a result of these field investigations, it was concluded that in a few instances, if the proposed alignments were slightly modified, significant reductions could be achieved in the expected impacts resulting from construction. Therefore, where these impacts could be reduced and were found to be appreciable, the alignment was modified to reflect the change. It should be noted here that realignment of the routes does not alter the conclusion derived in the engineering analysis, since the connection points remain unchanged. However, modifications to the route alignment would affect the overall length of the line and therefore would impact upon the project costs. These revised route lengths were used in determining the refined project costs for each route. Presented below is a description of the final route alignments along with revised lengths. Following this is a presentation of the methodology used and the resulting environmental impacts attributed to each route.

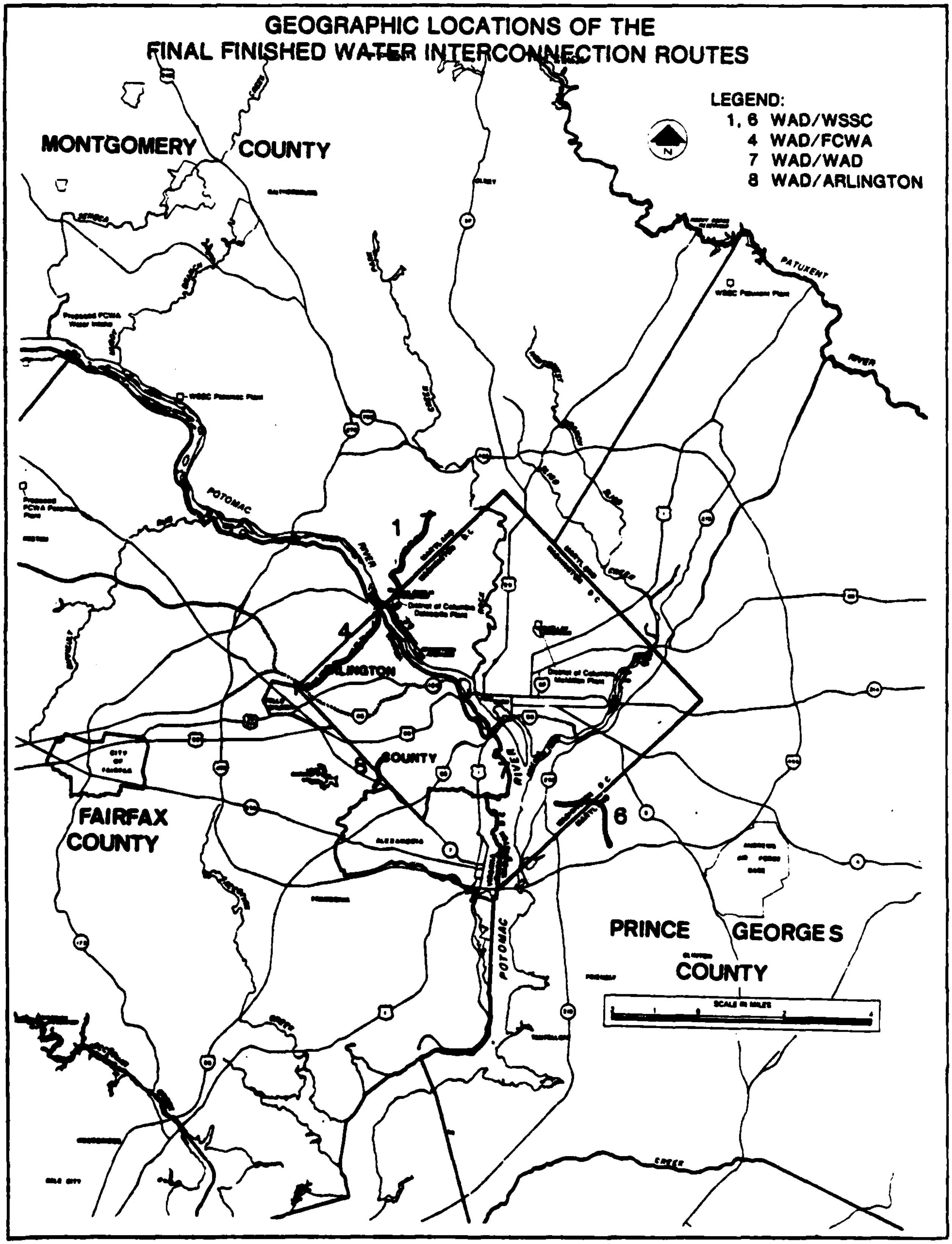


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Figure E-23

TABLE E-40
SUMMARY OF PRELIMINARY HYDRAULIC DATA AND CAPITAL COSTS
FOR THE FINAL FINISHED WATER INTERCONNECTIONS

Data	Routes				
	WAD -WSSC		FCWA - WAD		WAD -WAD[2]
	#1 Dalecarlia-Montgomery Main Service	#6 DC Low - Anacostia First High	#8 FCWA-Arlington County	#4 FCWA - WAD	#7 Arlington - Pentagon
Hydraulic Data					
Pipeline Capacity (mgd)	60	10 - 4	6 - 8	40	5-7
Pipeline Diameter (inches)	60	24 - 16	36	48	24
Pipeline length (feet)	16,000	9,000	9,000	40,000	1
Reversible Flow	yes	no	yes	no	yes
Project Costs[1] ($mill.)					
Potomac River Crossing	-	-	-	3.4	-
Pump Station(s)	2.6	1.1	-	2.0	-
Pipeline & Installation	3.8	.6	1.1	7.2	-
Repaving & Seal Cap	1.0	.4	.3	2.2	-
TOTAL	$7.4	$2.1	$1.4	$14.8	

[1] Costs in 1981 dollars.
[2] No preliminary costs were computed. Cost was assumed to be minimal (see text).

WAD - WSSC Route #1 - Dalecarlia-Montgomery Main Service

From the Dalecarlia Treatment Plant west along MacArthur Boulevard immediately east of the right-of-way of the B&O Railroad. North along the stream valley crossing Massachusetts Avenue. North-northeast paralleling Little Falls Parkway Road to Little Falls Parkway Road, to Little Falls Parkway, to its terminus approximately at the intersection with the B&O Railroad (Length = 17,000').

FCWA - WAD Route #4

From intersection of Capital Beltway and Interstate 66 east along I-66 to Williamsburg Boulevard, then along Williamsburg Boulevard to South Glebe Road (Route 120), north to and across Chain Bridge, then north along George Washington Memorial Parkway to Dalecarlia Water Treatment Plant (length = 40,000').

WAD - WSSC Route #6 - District of Columbia Low-Prince Georges Potomac Service

From intersection of Naval Research Laboratory main road and Anacostia Freeway east cross country to Galvaston Street. East along Galvaston Street to Indian Head Highway (South Capital Street), then south along Indian Head Highway to Madoc Street, east one block to Ottawa Street, and then south to Forest Heights Elevated Tank (10 mgd length = 9,950'; 4 mgd length = 1,500').

WAD - WAD Route #7 - Arlington - Pentagon

Interconnection at the intersection of Eads and 12th Streets, Arlington, Virginia. The length of pipe required for this interconnection is minimal since the pipes cross.

FCWA - Arlington Route #8

From intersection of Carlyn Springs Road and Arlington Boulevard south along Carlyn Springs Road, intersecting Columbia Pike at Leesburg Pike, then south along Seminary Road terminating at Calhoun Avenue (length = 8,600').

METHODOLOGY

In order to identify and measure the likely impacts of proposed actions, an appraisal of existing conditions in the MWA was required. The methodology used for this assessment was identical to the methodology described in the Raw Water Interconnection section earlier in Appendix E. An interdisciplinary team utilized existing reports, topographic maps, aerial photography, and field reconnaissance to develop a comprehensive assessment of the impacts associated with the various alternative routes.

Existing reports including master plans, local and regional plan proposals, land use zoning maps and other published materials were utilized so that local preferences for planning would receive ample consideration in the assessment process.

Revised 1:24,000 USGS topographic maps were useful in assessing the various routes with respect to the geographic areas that could potentially be affected. Transportation systems, utilities, drainage networks, topographic characteristics, and cultural information were extracted from this source.

The variance in use of land adjacent to a proposed project was considered an important determinant in the assessment and evaluation of impacts. For this reason, aerial photography provided a means to delineate a wide range of land uses. These various land uses were differentiated by examining the variety of tones, patterns, and spatial arrangements of ground objects. Controlled photomosaic at a scale of 1:24,000 was constructed using 1977 aerial photos with stereoscopic viewing capability.

To supplement the base information, field reconnaissance was also undertaken. These field surveys provided updated information not shown on the topographic maps or the more recent photographic coverage.

With the aid of these sources, finished water interconnections and treatment plant locations were identified on topographic maps and outlined on transparent overlays using recommendations set forth in local reports and publications. Land use overlays were then constructed through photographic interpretation of ground features. Specific land use categories were developed for areas devoted to residential, agricultural, commercial-industrial, public, recreational, forested, transportation, and utility uses. Drainage features were also delineated. Where applicable, a predetermined "impact corridor" was developed, since it was recognized that areas adjacent to the proposed routes could be affected to varying degrees during and after construction of the projects. This "impact corridor" was used to quantify the amount of lands, roads, and utilities that could be affected by the various interconnection routes. These factors in the impact corridor, used in the assessment of the finished water interconnection routes, are presented in Table E-41. A detailed description of these factors can be found in the Raw Water Interconnection section of this appendix.

RESULTS

The previous section presented the methodology used in assessing the environmental impacts of the interconnection alternatives. Table E-42 presents, in summary form, the numerical impacts associated with the finished water interconnection routes. Also included in this section is a more detailed discussion of the more important criteria and the specific areas affected by each proposed finished water interconnection route. It should be noted that a detailed impact assessment was not performed on the Arlington Pentagon route since it is confined to a point source location. Any impacts associated with this route would be negligible.

Route #1: Dalecarlia (WAD) - Montgomery Main Service

A major land use impact generated by this finished water interconnection route would be in the Little Falls Creek Valley. This narrow valley is central to the Little Falls Park and is an important open area in the highly developed Montgomery County suburb. It is valuable as a recreational area and is an aesthetically pleasing break from the high density surrounding development. Some temporary adverse impacts can be expected to occur to the Chessie System Railroad right-of-way that would be immediately west of the pipeline right-of-way. The major transportation corridors that would be affected by this pipeline are Massachusetts Avenue (Route 396) and River Road, both major thoroughfares conveying heavy average daily traffic. These disruptions, however, should be temporary only.

TABLE E-41

IMPACT FACTORS CONSIDERED

ECOLOGICAL

Miles of Pipelines
Number of 100-year Floodplain Crossings
Critical Wildlife Habitat Affected
Miles Through or Adjacent to Farmland Habitat
Threatened or Endangered Species Affected
Miles Through or Adjacent to Woodland Habitat

SOCIAL

Total Miles Along Transportation Routes
    Dual Road
    Primary Road
    Secondary Road
Number of Intersections with Transportation Routes
Miles Along Major Utility Rights-of-Way
Number of Intersections with Major Utilities
Number of Crossings Along Known Cultural Resources Sensitivity Areas
Number of Crossings Over Potential Cultural Resources Sensitivity Areas
Miles Adjacent to Land Use Type
    Agricultural
    Wooded Land
    Commercial/Industrial
    Recreational
Percent in High Density Areas

REAL ESTATE

Total Real Estate Cost
    Cost for Land
    Improvements Cost
    Severence Costs
    Relocation Costs
Number of Properties Affected

TABLE E-42

IMPACT ASSESSMENT FOR FINISHED WATER INTERCONNECTIONS

Impact Area	Routes				
	WAD-WAD #7 Arlington-Pentagon	WAD-WSSC #1 Dalecarlia Plant to Montgomery Main Service	WAD-FCWA #4 Dalecarlia Plant to I-66 & I-495 Interchange	WAD-WSSC #6 DC Low-Prince Georges Potomac Service	WAD-FCWA #8 Fairfax County Water Authority - Arlington
ECOLOGICAL					
Miles of Pipelines	.04	3.2	8.4	1.9	1.6
Number of 100 Year Floodplain Crossings	0	2	0	0	0
Critical Wildlife Habitat Areas Affected	None	None	None	None	None
Miles Through or Adjacent to Farmland Habitat	None	None	None	None	None
Threatened or Endangered Species Affected	None	None	None	None	None
Miles Through or Adjacent to Woodland Habitat	0	2	0	0	0
SOCIAL					
Total Miles Along Transportation Rts.	0	2.5	4.5	1.0	1.6
Dual Road	0	.75	0	0	.5
Primary Road	0	1.0	0	1.0	0
Secondary Road	0	.5	4.5	0	1.1
Number of Intersections with Transportation Routes	4	13	4	4	0
Miles Along Major Utility Rts. of Way	None	None	None	None	None
Number of Intersections with Major Utilities	None	None	None	None	None

TABLE E-42 CONTINUED

Impact Area	WAD-WAD #7 Arlington-Pentagon	WAD-WSSC #1 Dalecarlia Plant to Montgomery Main Service	WAD-FCWA #4 Dalecarlia Plant to I-66 & I-495 Interchange	WAD-WSSC #6 DC Low-Prince Georges Potomac Service	WAD-FCWA #8 Fairfax County Water Authority - Arlington
Number of Crossings Along Known Cultural Resources Sensitivity Areas	0	0	0	0	0
Number of Crossings Over Potential Cultural Resources Sensitivity Areas	low	low	low	low	low
Miles Adjacent to Land Use Type					
Agricultural	0	0	0	0	0
Wooded Land	0	2	2	1.5	0
Commercial/Industrial	0	2	1.5	0	0
Recreational	0	2	1.5	0	0
Percent of Affected Area in High Density Development	-	.33	100	.60	.75
REAL ESTATE					
Total Real Estate Costs ($millions)	-	8.2	10.7	6.4	5.6
Cost for Land	-	5.0	6.3	2.5	2.5
Improvements Costs	-	1.3	1.3	1.3	1.3
Severence Costs	-	1.3	1.3	1.3	1.2
Relocation Costs	-	.6	1.8	1.3	.6
Number of Properties Affected	0	100	300	100	50

The proposed right-of-way follows Little Falls Stream Valley for approximately 8,000 feet. This stream valley, known as Little Falls Branch Park, is a conservation area of the Maryland National Capital Parks and Planning Commission that protects the ecological value of the stream valley. The impacts from construction activities would be mainly in the park's value as a wildlife habitat and corridor and as a visual resource. In addition, Westmoreland Hills Recreation Center, a local community park, exists in Little Falls Branch Park. Impacts would depend on the alignment of the right-of-way, but there is the possibility of impacting some of the recreational activities (playgrounds, ballfields, picnic areas) either physically or by reducing the amount of use due to noise and visual impacts.

This route utilizes the floodplain of Little Falls Creek for a distance of 2.0 miles. Fish and wildlife impacts to this area would be significant as riparian and floodplain vegetation would be altered or removed. Assuming an approximate 100-foot right-of-way, this route could potentially impact as much as 23 acres of this type of habitat in the Little Falls Creek area. The route also requires five stream crossings which could result in additional permanent loss of habitat as well as temporary impacts in the stream.

<u>Route #4: Fairfax County Water Authority - Washington Aqueduct Division</u>

This interconnection principally utilizes the alignment of Interstate 66 south from the Capital Beltway (Interstate 495) in Virginia. With its present right-of-way, land use impacts would not be significant until the intersection with Williamsburg Boulevard in Arlington County. Impacts to the section along Williamsburg Boulevard would be to the residences along this collector roadway in terms of temporary inconveniences during construction phasing. The section along Glebe Road to Chain Bridge is entirely a neighborhood of single family housing and would therefore be also subject only to interim construction and operation and maintenance impacts. It is planned that the water line would be suspended from the superstructure of Chain Bridge thereby avoiding impacts resulting from construction activity in the Potomac River. Impacts to the George Washington Memorial Parkway would not be any different from those occurring to any other roadway except perhaps that additional sensitivity would be required to restore the visual appeal and other aesthetics of this noted highway. Again, after construction, any impacts would be minimal, restricted to any necessary maintenance.

The proposed right-of-way passes near the Falls Church City Park and the Minor Hill Reservoir Recreation Area. Both the local parks have a variety of recreational activities associated with them. Possible impacts would be noise, visual disruption, and inadequate access. Additionally, since the route follows existing transportation routes, impacts to fish and wildlife are minimal.

<u>Route #6: DC Low and Anacostia First High - Prince Georges Potomac Service</u>

This route has land use impacts in the southwestern section of the District of Columbia and a small contiguous section of Prince Georges County. The area expected to experience impacts is unique in terms of its overall land use. Samples of almost all major land use categories are evident. The area contains major Federal and local governmental installations, such as the U.S. Naval Research Laboratory, the District of Columbia Fire Training Academy, and D.C. Village. Also present are commercial areas, medium to high density residential settlements, low production value fresh water tidal flats and utility transmission structures. However diverse the existing land use, the construction of this finished water pipeline is not expected to have lasting adverse

impacts due to the availability of open space that can accommodate a finished water interconnection pipeline while thus maintaining the existing land use network. Post-construction impacts would be proportional to the need for maintenance to the pipeline should cleaning or replacement become necessary. In either of these situations, impacts would be equal to those experienced during installation construction.

No recreation facilities would be impacted, and furthermore, since the fish and wildlife habitat in the affected area is of low value, the impacts that could be expected to occur would have a minimal effect on the environment.

Route #8: Fairfax County Water Authority - Arlington County

This interconnection transversus a densely populated region of Northern Virginia that contains a land use mixture made up primarily of commercial and residential areas. Small recreation facilities along with public and institutional establishments such as schools and a hospital are also present. The proposed pipeline right-of-way is planned to parallel existing arterial roadways that convey a high volume of traffic during rush hours and a large daytime traffic. With a high density residential population housed in nearby high rise and garden apartments and single-family houses, temporary but significant impairment to the area's aesthetics can be expected to occur. Noise, dirt, vibration, and visual impacts are certain. Traffic congestion would be present in the vicinity of active construction sites and staging areas. This congestion would not only affect the commuters in the immediate vicinity of the pipeline right-of-way but also would impact commuters living in more removed sectons of the Northern Virginia suburbs. An example are those who utilize such routes as Carlyn Springs Road, Columbia Pike, and Arlington Boulevard for transportation into the more central part of the Washington Metropolitan Area. As with any other finished water route, long term impacts would be insignificant except for instances where the pipeline has to be excavated for maintenance and operation.

The proposed right-of-way crosses Long Branch Stream which is part of the Long Branch Nature Center. The possible impacts that could be expected to occur are as follows: noise and visual impacts from construction activities as well as access to the center which could reduce the amount of use at the center. Additionally, since the affected area is highly developed, it is not expected that the route would impact any significant fish and wildlife resources.

DESIGN AND COST ANALYSIS OF FINAL ROUTES

The third phase of the finished water interconnection analysis consisted of developing conceptual engineering designs and detailed project costs for each of the final five interconnections. In order to accomplish this task, the Baltimore District contracted with the consulting engineering firm of Hayes, Seay, Mattern and Mattern. The contractor's work effort consisted of using the engineering and revised route alignment data generated as a result of Phase One and Two analyses and expanding upon this information to develop detailed project costs and engineering designs for the major components of each interconnection.

Construction costs and engineering designs were developed for both the pipelines and pump stations. Operations and maintenance (O&M) costs were developed for the pump stations only. O&M costs attributable to the pipeline itself were assumed to be borne by the maintenance staffs of the water supply agencies in which whose jurisdiction the project would be constructed.

PIPELINES

All costs estimated were based on non-site specific concept designs for the pipelines, and were developed in the same manner as costs for the raw water interconnections (see previous section of this appendix). Table E-43 is a summary of the pipeline unit costs as expressed in October 1981 price levels.

TABLE E-43

FINISHED WATER PIPELINE UNIT COSTS*
(October 1981 Prices)

		Dollars Per Linear Foot		
Construction Terrain	24"	36"	48"	60"
Open Area	$67	$112	$178	$264
Open Area in Road	94	147	300	400
Urban Area	156	219	304	406
Urban Area in Street	183	254	347	453
Highway and RR Crossing	413	836	927	1,052
River Crossing	-	-	2,420	-

* Excludes add-on items such as rock excavation, blow-off valves, air relief valves, valve vaults.

PUMP STATIONS

The design concepts for the finished water pump stations were based on two basic sizes - 20 mgd and 40 to 50 mgd. The smaller booster station would be used for the Naval Research Lab, and Owens Road locations. It uses horizontal split case pumps arranged on an in-line configuration, using minimum angular fittings to reduce head loss. Multiple pumps would be provided with one stand-by for emergency use. The larger size station, used at the Dalecarlia site, would also use horizontal split case pumps. Pumps large enough to supply water to WAD-WSSC-1 and WAD-FCWA-2 would be included in the same building. The station would take water from an existing 8 foot water conduit from the 30 million gallon clear water basin. The pumps would be arranged to pump to the two systems independently.

All pump station design concepts were based on meeting the design requirements of the Ten State Standards, and Hydraulic Institute Standards, 13th Edition. All stations were designed to provide adequate working space and safe working conditions. Traveling bridge cranes were provided for pump maintenance and removal. All pump room interiors would have acoustical treatment on the walls and ceilings to reduce the noise level. In addition, an acoustically isolated room would be provided for operators' use. In the small booster stations, toilet facilities would be provided for the operators' convenience. No emergency power generation facilities were incorporated in this preliminary concept design. If standby power is a requirement, two sources of power (power from two distribution systems) should be investigated during the design phase. Table E-44 contains a complete list of the finished water pumping stations with capacities and other pertinent data.

TABLE E-44

DESIGN DATA FOR FINISHED WATER PUMPING STATIONS

ROUTE	FLOW DIRECTION	FLOW MGD	FLOW GPM	TOTAL HEAD-FT.	NUMBER PUMPS*	CAPACITY PER PUMP-GPM	INSTALLED HP PER PUMP
WAD-WSSC #1	Dalecarlia to Chevy Chase Terrace	60	41,667	386	4	14,000	2,000
WAD-WSSC #6	Naval Research Lab to Forest Heights	10	6,944	221	2	7,000	500
WAD-WSSC #6	Anacostia First High to Prince Georges Potomac	4	2,778	100	2	2,800	200
WAD-FCWA #4	Dalecarlia to I-66 & I-495 Interchange	40	27,778	453	3	14,000	2,000

* Includes one standby unit.

Construction costs for the finished water pumping stations were based on the design considerations previously discussed. Costs for architectural, civil, electrical, structural, and heating and ventilation items have been included in the cost estimate. Contractor's overhead and profit, site and design contingency, bonding costs and costs for civil-electrical coordination have also been added to arrive at a total construction cost.

Experience has indicated that projects involving process equipment such as pumps, motors and control systems require field coordination between the various trades installing the equipment. This coordination is required to insure compatibility between equipment and control systems and to insure that pumping operations will function in accordance with design specifications. Costs for civil-electrical coordination have therefore been added to account for field coordination requirements.

Costs for pumping stations presented are based on non site-specific design concepts and must be refined when site specific criteria such as soil and subsurface conditions, availability of utilities, accessibility and construction difficulties have been determined.

Station equipment costs, such as pumps and motors, valves, interior piping, monorails and traveling bridge cranes were obtained from manufacturers who quoted equipment prices and costs for shipment to the Washington area. Man-hour requirements for pump and motor installation were obtained from Richardson's Process Plant Construction Estimating Standards.

OPERATION AND MAINTENANCE COSTS

Operation and maintenance costs for the finished water pumping stations were developed based on four parameters: personnel, energy, fixed maintenance, and variable maintenance. The costs were developed on a per day basis assuming that the pumping stations would operate for one continuous 24 hour period at 100 percent of the pump station capacity.

RESULTS

The following section presents a breakdown of the estimated construction, and operation and maintenance costs specific to each finished water interconnection route. Costs are listed separately for pipeline construction, pumping station construction, land acquisition, and operation and maintenance.

Also presented in Figures E-24 through E-29 are the engineering drawings specific to each route. The drawings consist of a plan view of the route alignment indicating direction of flow and location of pumping station(s); and a line profile highlighting major transporation, stream and river crossings, location of air relief and blow-off valves, and types of construction categories traversed.

Table E-45 is a summary of the total cost of each route. Table E-46 presents a breakdown of the operation and maintenance cost of each pump station. Table E-47 presents a detailed cost estimate for Interconnection Route #1 as developed by the Corps. For the other routes, similar detailed estimates were also developed but are not presented. However, total costs for each route are shown in Table E-45.

Subsequent to the interconnection analysis, proposed legislation was submitted to Congress to permit the sale of water from the Federally-owned Washington Aqueduct to the Washington Suburban Sanitary Commission. This legislation would allow the construction of a finished water interconnection (Route #1) between the Aqueduct and WSSC to provide more efficient management of existing supplies. Negotiations between the Corps of Engineers and WSSC regarding a contract for the 60 mgd interconnection can proceed whenever such authorization is enacted.

The WSSC has completed detailed design of the project, and has estimated a total construction cost of $34,795,000 (October 1981 price level). This estimate is broken down as follows: $7,044,000 for 17,000 feet of 60-inch diameter pipe and associated valves, vaults, etc; $4,467,000 for a 60 mgd pump station including four pumps; $7,624,000 for real estate costs including ROW acquisition, improvements, severence, and relocation costs; and $15,660,000 for upgrading and improvements at Dalecarlia to make the 60 mgd potential capacity available for use. (It should be noted that the Corps' estimated cost of $21,200,000 shown in Table E-45 for Route #1 did not include the $15,660,000 for modifying the Dalecarlia treatment plant).

TABLE E-45

TOTAL COSTS FOR FINISHED WATER INTERCONNECTIONS
($1,000,000 - October 1981 Prices)

LINE DESTINATION	PIPELINE	PUMP STATION	LAND	TOTAL	O & M*
WAD-WSSC #1	7.4	5.0	8.8	21.2	0.16
WAD-WSSC #6	1.9	2.2	6.7	10.8	0.09
WAD-FCWA #8	2.4	-	6.1	8.5	-
WAD-FCWA #4	20.0	3.0	11.4	34.4	0.13
WAD-WAD #7	.07	-	-	.07	-

* Based on pump station operation of 30 days @ 24 hours per day continuously.

CONCLUSIONS

As a result of the engineering, environmental, and cost impact analysis, several conclusions can be drawn concerning finished water interconnections and their role in helping solve the MWA water supply problems. These conclusions are as follows:

1. They do not provide additional supply to the region, rather they provide added efficiency and "fail-safe" capability to the three major water service areas (WSSC, WAD, and FCWA) in the event of failures in one part of the respective distribution systems.

2. They make use of potential treatment capacity at the WAD. Therefore, the construction of new treatment facilities for additional peaking capacity at other water utilities may be negated or delayed.

3. They may improve the environmental quality of the Potomac River upstream of the WAD intake by keeping more water in the river resulting in reducing the impacts associated with otherwise increased withdrawals.

4. They could provide potential cost savings to the water service areas through the construction of pipelines rather than constructing additional treatment facilities.

5. They require regional coordination and/or interagency agreement for purchase of water and construction of pipelines.

6. Finished water interconnections between the Washington Aqueduct and WSSC are contingent upon Congressional authorization to approve the sale of water.

TABLE E-46

O&M COSTS FOR FINISHED WATER INTERCONNECTION PUMPING STATIONS

LINE DESIGNATION	PERSONNEL $/DAY	ENERGY $/DAY	FIXED MAINT. $/DAY	VARIABLE MAINT. $/DAY	TOTAL COST $/DAY	TOTAL COST $/MONTH
WAD-WSSC #1 Dalecarlia 60 mgd	190	5,100	25	25	5,340	160,000
WAD-WSSC #6 Naval Research Lab 10 mgd	190	2,600	25	20	2,840	85,000
WAD-FCWA #8 Owens Road 10 mgd	190	230	25	4	450	13,500
WAD-FCWA #4 Dalecarlia 40 mgd	190	4,000	25	20	4,200	126,000

ASSUMPTIONS: 1. 1 day for 24 hours

2. 30 days for 24 hours/day

TABLE E-47

DETAILED COST ESTIMATE FOR WAD-WSSC
FINISHED WATER INTERCONNECTION #1
(October 1981 Prices)

I. PIPELINE CONSTRUCTION COSTS

Construction Terrain	Total Feet	$/Foot		
Open Area	8,850	264	=	$2,336,000
Open Area in Road	4,150	400	=	1,660,000
Urban Area	-	406	=	—
Urban Area in Street	3,500	453	=	1,586,000
Highway and RR Crossing	500	1,052	=	526,000
River Crossing	-	-	=	-
	CONSTRUCTION SUBTOTAL			$6,108,000
add-on items:				
Rock in Type 1	-	$83/LF	=	-
Rock in Type 2	-	$83/LF	=	-
Rock in Type 3	-	$117/LF	=	-
Rock in Type 4	-	$117/LF	=	-
Air Relief Valves	3	$15,500 EA	=	$47,000
Blow-offs	3	$2,600 EA	=	8,000
Valve Vaults	7	$39,000 EA	=	273,000
	ADD-ON SUBTOTAL			$328,000
	PIPELINE SUBTOTAL			6,436,000
	15% DESIGN CONTINGENCY			965,000
	PIPELINE TOTAL			$7,401,000

II. PUMPING STATION COSTS

Station: Dalecarlia
Size: 60 mgd
Installed Horsepower Per Pump: 2,000
Pumps Installed: 4 @ 14,000 gpm each (includes 1 stand-by pump)

TABLE E-47 (continued)

Construction Costs:

Architectural Costs		$55,000
Civil Costs (includes cost of pumps)		1,266,000
Electrical Costs		112,000
Structural Costs		2,124,000
Heating & Ventilating Costs		231,000
Civil-Electrical Coordinating Fee: (10% Civil-Electrical Costs)		138,000
	CONSTRUCTION SUBTOTAL	3,926,000
	BOND (1%)	39,000
	SUBTOTAL	3,965,000
	SITE AND DESIGN CONTINGENCY	991,000
	PUMPING STATION TOTAL	$4,956,000

III. LAND COSTS

Land		$5,400,000
Improvements		1,350,000
Severance		1,350,000
	SUBTOTAL	$8,100,000
Cost of Relocation Home & Businesses		700,000
	LAND TOTAL	$8,800,000

IV. TOTAL ESTIMATED COST THIS LINE (I, II, III) $21,157,000

V. OPERATIONS AND MAINTENANCE COSTS ($/day)

Personnel		$190
Energy		5,100
Fixed Maintenance		25
Variable Maintenance		25
	TOTAL O&M COSTS	$5,340

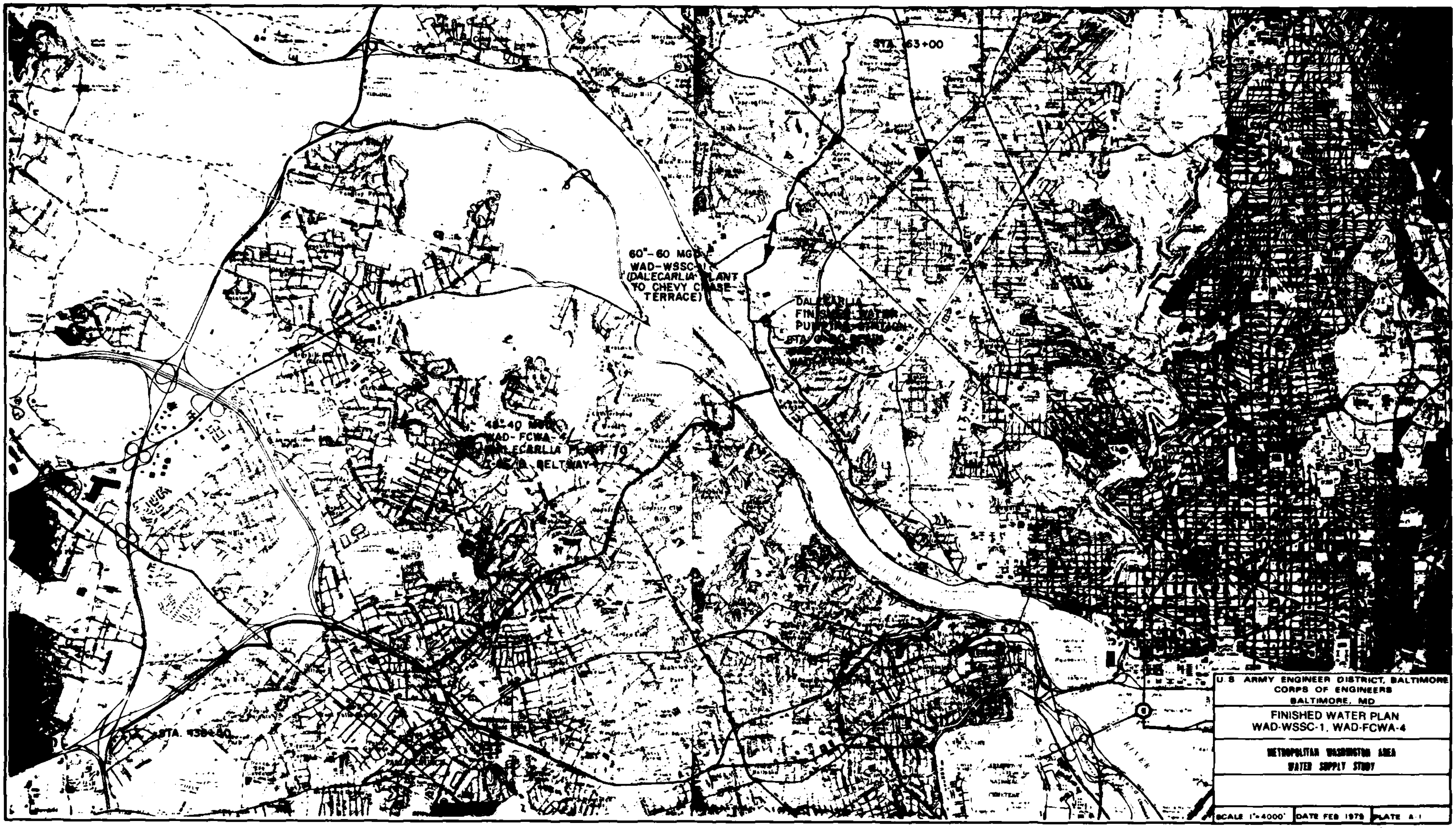

STA. 63+00
60"-60 MGD
WAD-WSSC-1
(DALECARLIA PLANT
TO CHEVY CHASE
TERRACE)
DALECARLIA
FINISHED WATER
PUMPING STATION
48"-40 MGD
WAD-FCWA-4
DALECARLIA PLANT TO
BELTWAY
STA. 435+00
RIVER
U S ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MD
FINISHED WATER PLAN
WAD-WSSC-1, WAD-FCWA-4
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
SCALE 1"=4000'
DATE FEB 1979
PLATE A-1

Figure E-24

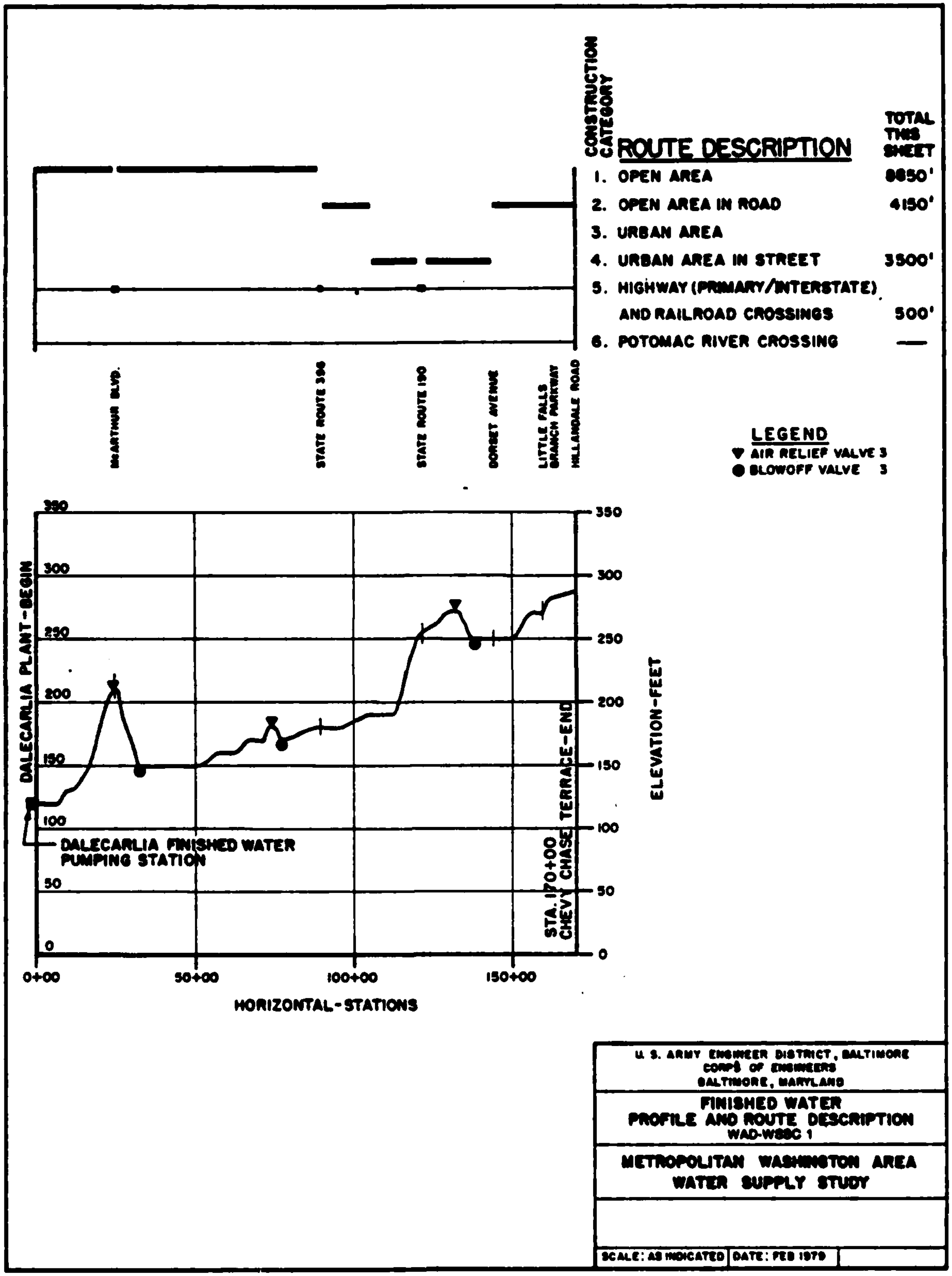
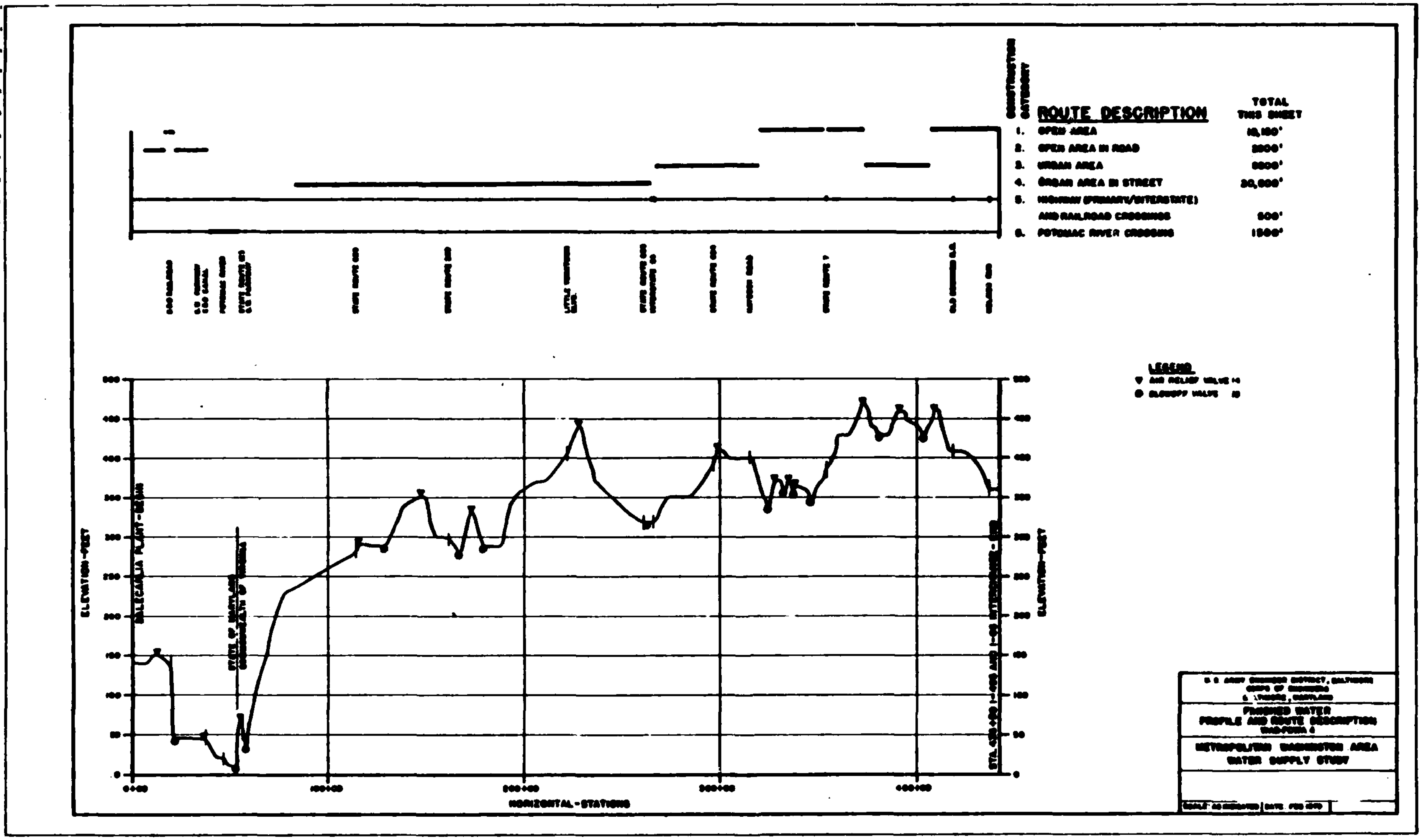

CONSTRUCTION CATEGORY
ROUTE DESCRIPTION
TOTAL THIS SHEET
1. OPEN AREA 8850'
2. OPEN AREA IN ROAD 4150'
3. URBAN AREA
4. URBAN AREA IN STREET 3500'
5. HIGHWAY (PRIMARY/INTERSTATE) AND RAILROAD CROSSINGS 500'
6. POTOMAC RIVER CROSSING —
McARTHUR BLVD.
STATE ROUTE 396
STATE ROUTE 190
DORSET AVENUE
LITTLE FALLS BRANCH PARKWAY
HILLANDALE ROAD
LEGEND
▼ AIR RELIEF VALVE 3
● BLOWOFF VALVE 3
DALECARLIA PLANT-BEGIN
DALECARLIA FINISHED WATER PUMPING STATION
STA. 170+00 CHEVY CHASE TERRACE-END
ELEVATION-FEET
HORIZONTAL-STATIONS
0+00
50+00
100+00
150+00
0
50
100
150
200
250
300
350
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND
FINISHED WATER
PROFILE AND ROUTE DESCRIPTION
WAD-WSSC 1
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
SCALE: AS INDICATED
DATE: FEB 1979

Figure E-25



ROUTE DESCRIPTION
TOTAL THIS SHEET
1. OPEN AREA 10,100'
2. OPEN AREA IN ROAD 2800'
3. URBAN AREA 8800'
4. URBAN AREA IN STREET 30,000'
5. HIGHWAY (PRIMARY/INTERSTATE) AND RAILROAD CROSSINGS 500'
6. POTOMAC RIVER CROSSING 1500'
LEGEND
ELEVATION-FEET
HORIZONTAL-STATIONS
DALECARLIA PLANT-BEGIN
METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY

Figure E-26

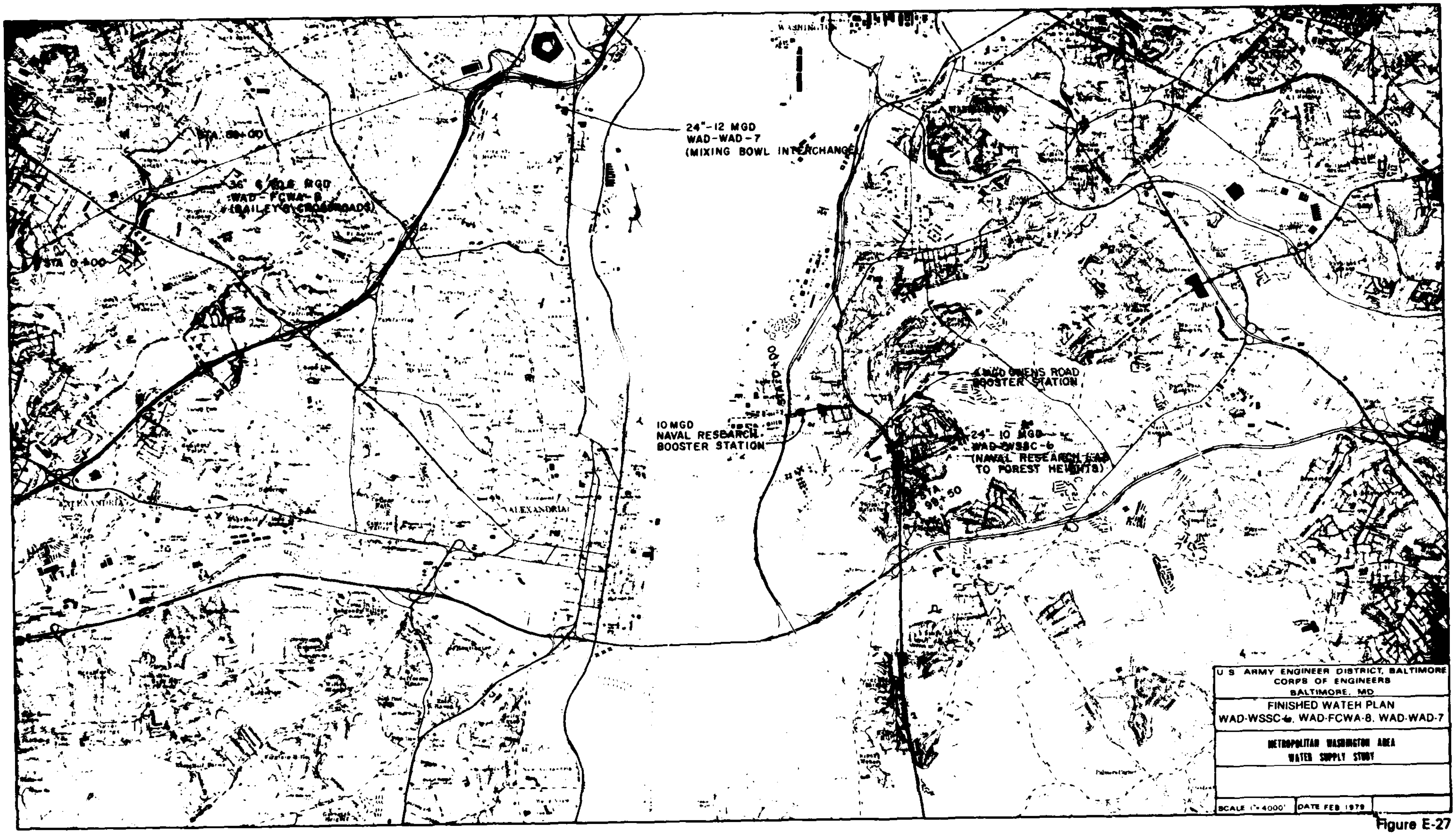

24"-12 MGD
WAD-WAD-7
(MIXING BOWL INTERCHANGE)
10 MGD
NAVAL RESEARCH
BOOSTER STATION
24"-10 MGD
WAD-WSSC-6
(NAVAL RESEARCH LAB TO FOREST HEIGHTS)
BOOSTER STATION
ALEXANDRIA
U S ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MD
FINISHED WATEH PLAN
WAD-WSSC-6, WAD-FCWA-8, WAD-WAD-7
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
SCALE 1"=4000'
DATE FEB 1979

Figure E-27

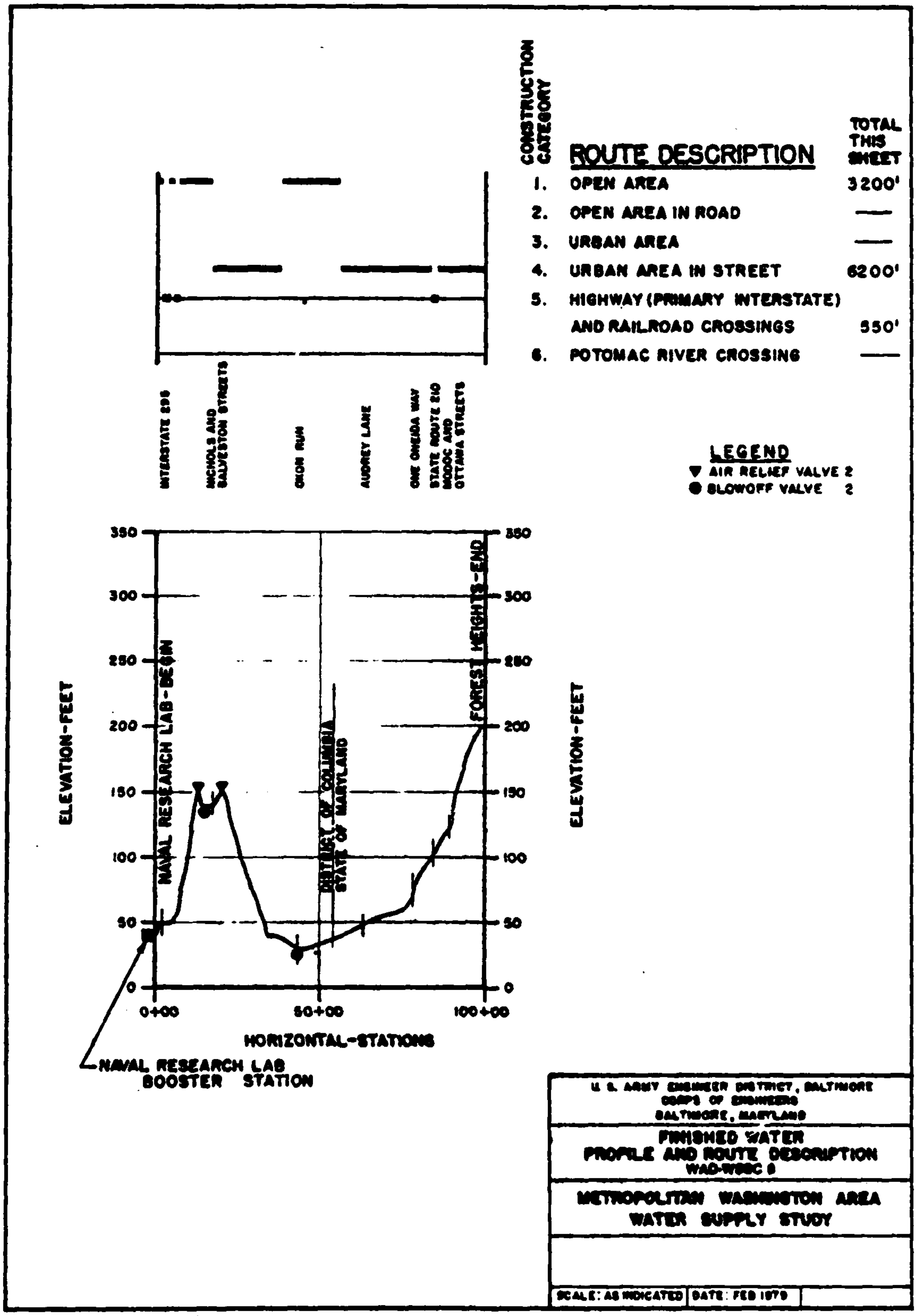
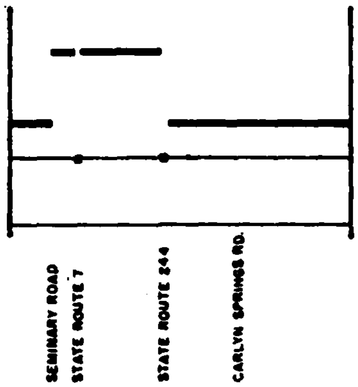

CONSTRUCTION CATEGORY
ROUTE DESCRIPTION
TOTAL THIS SHEET
1. OPEN AREA 3200'
2. OPEN AREA IN ROAD
3. URBAN AREA
4. URBAN AREA IN STREET 6200'
5. HIGHWAY (PRIMARY INTERSTATE) AND RAILROAD CROSSINGS 550'
6. POTOMAC RIVER CROSSING
INTERSTATE 295
NICHOLS AND GALVESTON STREETS
OXON RUN
AUDREY LANE
ONE ONEIDA WAY
STATE ROUTE 210
MODOC AND OTTAWA STREETS
LEGEND
AIR RELIEF VALVE 2
BLOWOFF VALVE 2
ELEVATION-FEET
NAVAL RESEARCH LAB-BEGIN
DISTRICT OF COLUMBIA
STATE OF MARYLAND
FOREST HEIGHTS-END
HORIZONTAL-STATIONS
0+00
50+00
100+00
NAVAL RESEARCH LAB BOOSTER STATION
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND
FINISHED WATER
PROFILE AND ROUTE DESCRIPTION
WAD-WSSC
METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY
SCALE: AS INDICATED
DATE: FEB 1979

Figure E-28

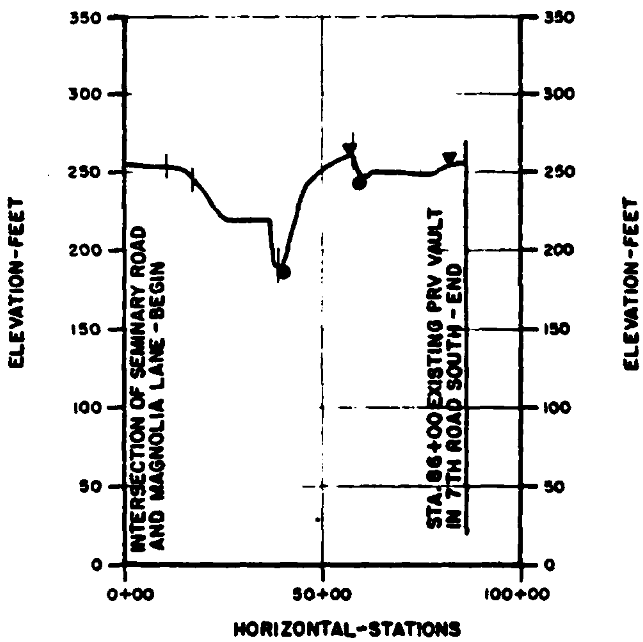
CONSTRUCTION CATEGORY	ROUTE DESCRIPTION	TOTAL THIS SHEET
1.	OPEN AREA	
2.	OPEN AREA IN ROAD	2600'
3.	URBAN AREA	
4.	URBAN AREA IN STREET	5700'
5.	HIGHWAY (PRIMARY INTERSTATE) AND RAILROAD CROSSINGS	300'
6.	POTOMAC RIVER CROSSING	



LEGEND

▼ AIR RELIEF VALVE 2

● BLOWOFF VALVE 2



U. S. ARMY ENGINEER DISTRICT, BALTIMORE CORPS OF ENGINEERS BALTIMORE, MARYLAND
FINISHED WATER PROFILE AND ROUTE DESCRIPTION WAD-FCWA 8
METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY
SCALE: AS INDICATED | DATE: FEB 1979

Figure E-29

REREGULATION

GENERAL

A third component that can be used as a means of averting local water supply shortages within the MWA is regulation. This alternative utilizes the existing internal finished water interconnections within a given water service area which is served by both a river and a reservoir source. During normal conditions, the water service area is served largely from the river source, thereby conserving storage in the reservoir. During a low flow condition in the river, however, a greater area is served from the reservoir which decreases the required withdrawal from the river source. This mode of operation requires a flexible distribution system (pipes, pumps, and water treatment facilities) which can be served by either of two sources. This type of internal finished water interconnection, called reregulation, is shown in Figure E-30. The solid dark area in this figure is the region that can "float" between the two sources of supply, depending on water availability. The concept of reregulation and its rules of operation were originally developed by the Interstate Commission on the Potomac River Basin (ICPRB).

In an effort to illustrate and define the engineering principles behind reregulation, the 1930-1932 drought conditions were simulated on the Potomac River for the MWA. This time frame was chosen because it represented, on a 30-day basis, the worse low flow conditions experienced on the Potomac River for the period of record (1930 to present) at Washington, D.C.

The following sections present the methodology, assumptions, and operating rules developed and used in performing the simulation. In addition, two sections discuss the operational impacts attributable to the implementation of reregulation and the benefits that can be realized from reregulation based on the simulation.

ENGINEERING ANALYSIS

The internal finished water interconnections that exist and link together the sub-distribution systems within a water service area (WSSC, FCWA) provide the overall finished water distribution system with the flexibility required to vary the proportion of demand met by withdrawals from different sources (Potomac River, WSSC Patuxent and FCWA Occoquan Reservoirs). Given this flexibility, however, optimization of both sources (river and reservoir) in conjunction with increasing the dependable yield of the overall distribution system is highly dependent upon two factors: (1) the daily operation of the finished water system; and (2) more importantly, upon the operational rules used to determine and regulate the relative quantities of water that can be withdrawn from each source at different times during the year. While it may be desirable to maintain high storage levels in the local offstream reservoirs, several additional factors must be weighed if efficient and orderly operation of the distribution system is to be maintained. These other factors are evaluated based on the collection of and generation of practical operational data for the following:

1. Maximum and minimum average monthly withdrawal rates for the treatment plants located near the WSSC Patuxent and the FCWA Occoquan reservoirs.

2. Useable storage allocated for water supply purposes, evaporation losses, required downstream releases, and natural or artificial inflows.

REPRESENTATION OF REREGULATION OPERATION

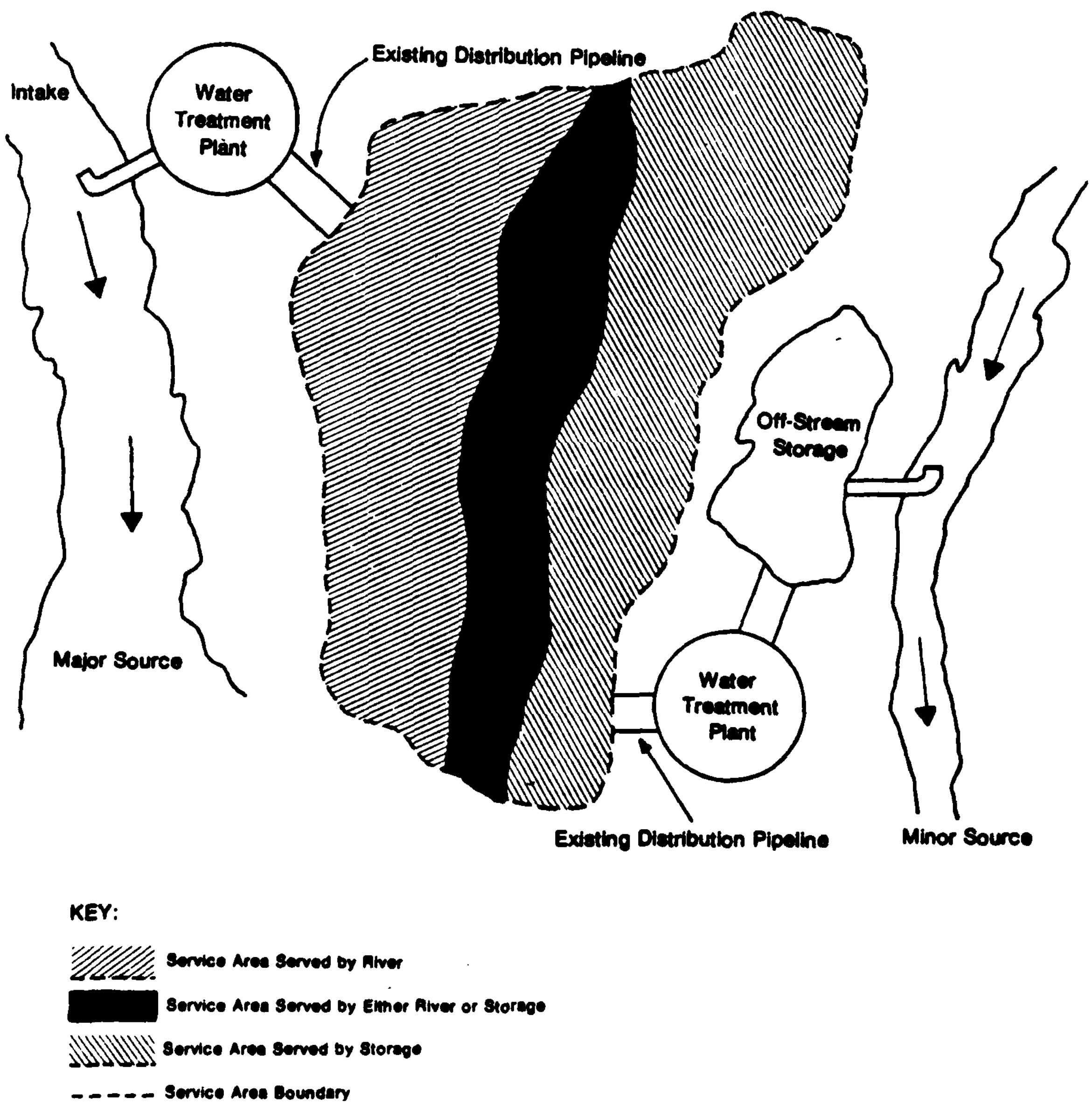


Figure E-30

The following paragraphs discuss the rationale used in generating these operational data. The first factor to be addressed is the determination of the maximum withdrawal rates at the WSSC and FCWA reservoir water treatment plants. The dependable monthly yield of either system is defined as being no more than the lowest monthly flow in the Potomac River for a given month plus the Bloomington Reservoir releases for that month plus the combined treatment capacity of the local reservoir treatment plants. Although storage in the reservoirs may be approaching maximum levels when low flow conditions exist in the Potomac River, the volume of water withdrawn from the reservoirs cannot be greater than the maximum treatment capacity of the reservoir water treatment plants which was determined to be 65 mgd for the WSSC Patuxent plant and 112 mgd for the FCWA Occoquan plant. Furthermore, these treatment plants cannot be operated at maximum capacity on a continuous basis. The practicalities of operation, including filter backwashing and normal maintenance, preclude running the plants at maximum capacity on a continuous basis. Subsequent conversations with the local utility managers indicated that 75 percent of the maximum capacity was a reasonable estimate of average monthly capacity. Applying this percentage to both the WSSC and FCWA reservoir water treatment plants, the average monthly water treatment plant capacities were computed to be 49 and 84 million gallons per day (mgd), respectively.

Also included as part of the reregulation scheme was the development of minimum treatment plant capacities. Through conversations with the local water authorities, the minimum monthly average flow requirement necessary to maintain safe operating conditions at the reservoir plants was found to be 20 mgd for the Patuxent and 30 mgd for the Occoquan.

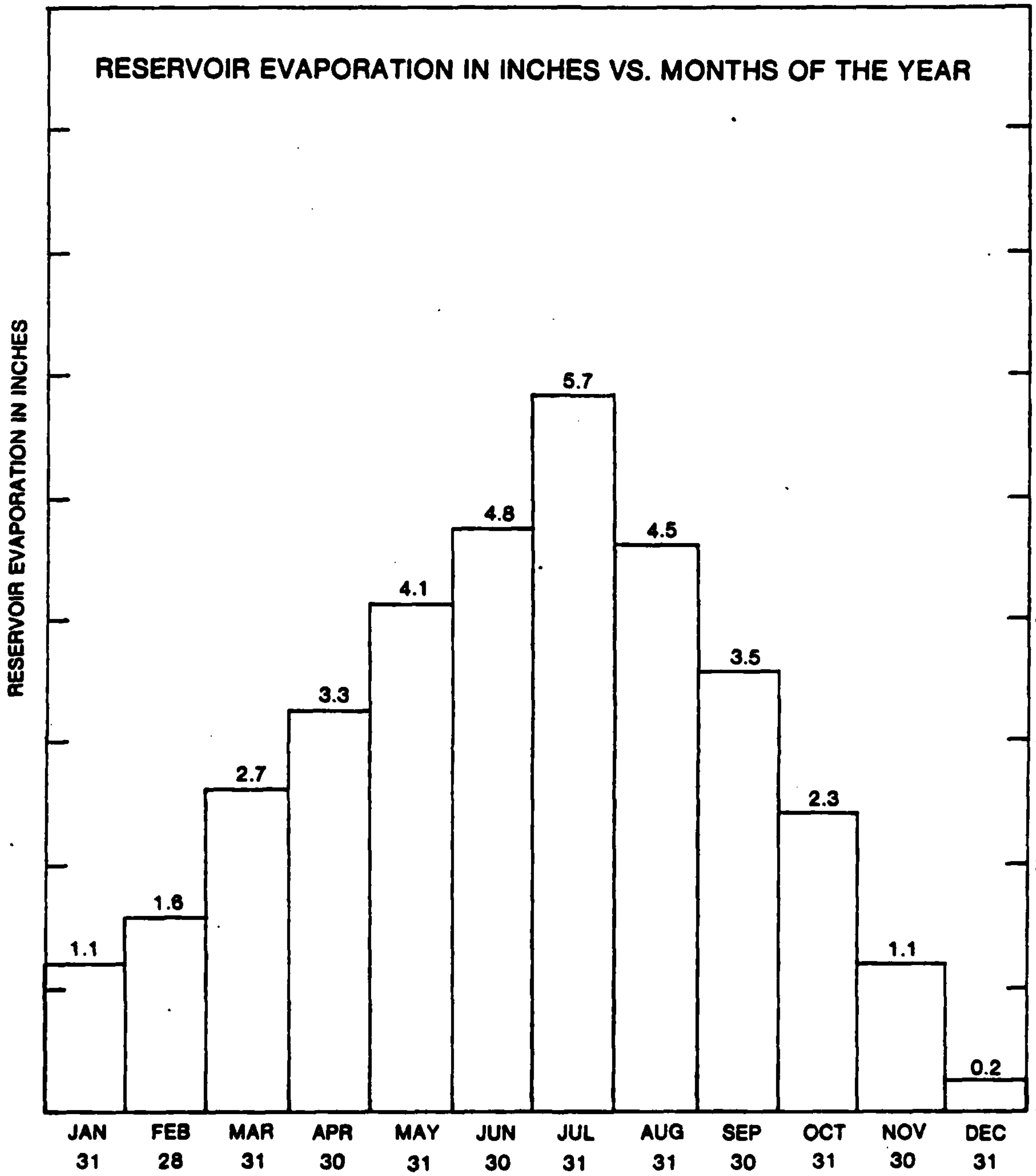
The next set of required data consisted of obtaining specific information for the Patuxent and Occoquan reservoirs. This information included useable storage, inflows, required downstream releases (where applicable), and reservoir evaporation losses. Required downsteam releases and inflow values were previously defined and can be found in the Appendix D - <u>Supplies, Demands and Deficits</u>. The combined usable water supply storage capacity of the two Patuxent Reservoirs, Triadelphia and Rocky Gorge, was 10.0 billion gallons. For the FCWA, the useable reservoir for the Occoquan Reservoir was 10.2 billion gallons. This value includes the 1.1 bg of storage which was added to the Occoquan Reservoir when the height of the dam was recently raised two feet.

The next step involved determining the volume of water lost by the reservoir through evaporation. This calculation was necessary in order to present a more accurate representation of the reservoir storage levels. To aid in the determination of evaporative losses, a histogram (Figure E-31) was developed showing evaporation loss in inches versus the various months of the year.

This graph was developed based on measurements made by the National Weather Service for 29 years of record. Additionally, composite area-storage curves were developed for the Occoquan reservoir (Figure E-32) and the Patuxent reservoir systems (Figure E-33). The information presented in these three figures were used in conjunction with the following equation to compute evaporative composite reservoir losses in mgd:

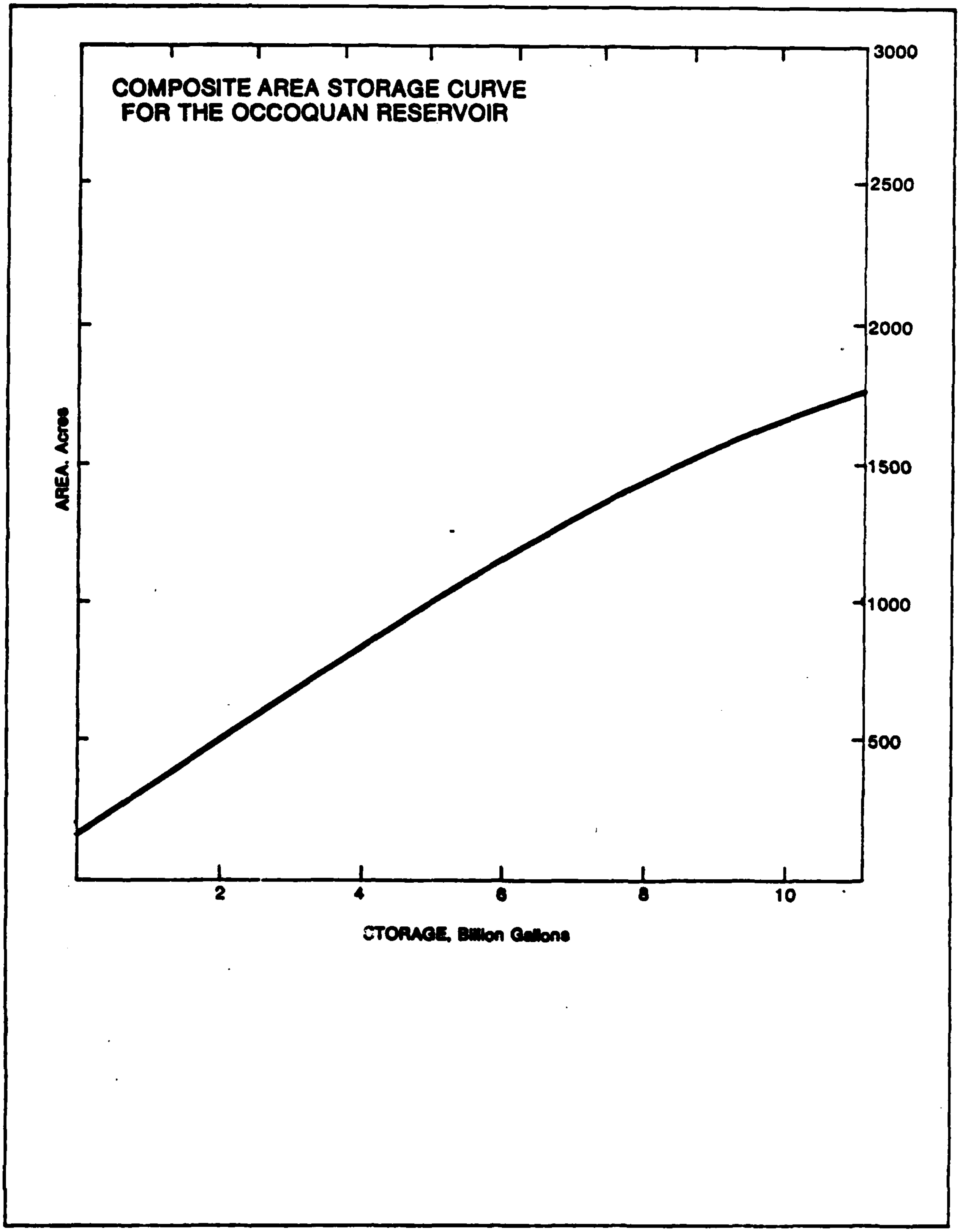
$$E = .02715 \frac{(ER \times A)}{D}$$

where E is the combined evaporative loss in mgd; ER is the evaporation rate in inches (from Figure E-31); A is the surface area of the theoretical combined reservoirs in acres; and D is the number of days in the month under analysis.



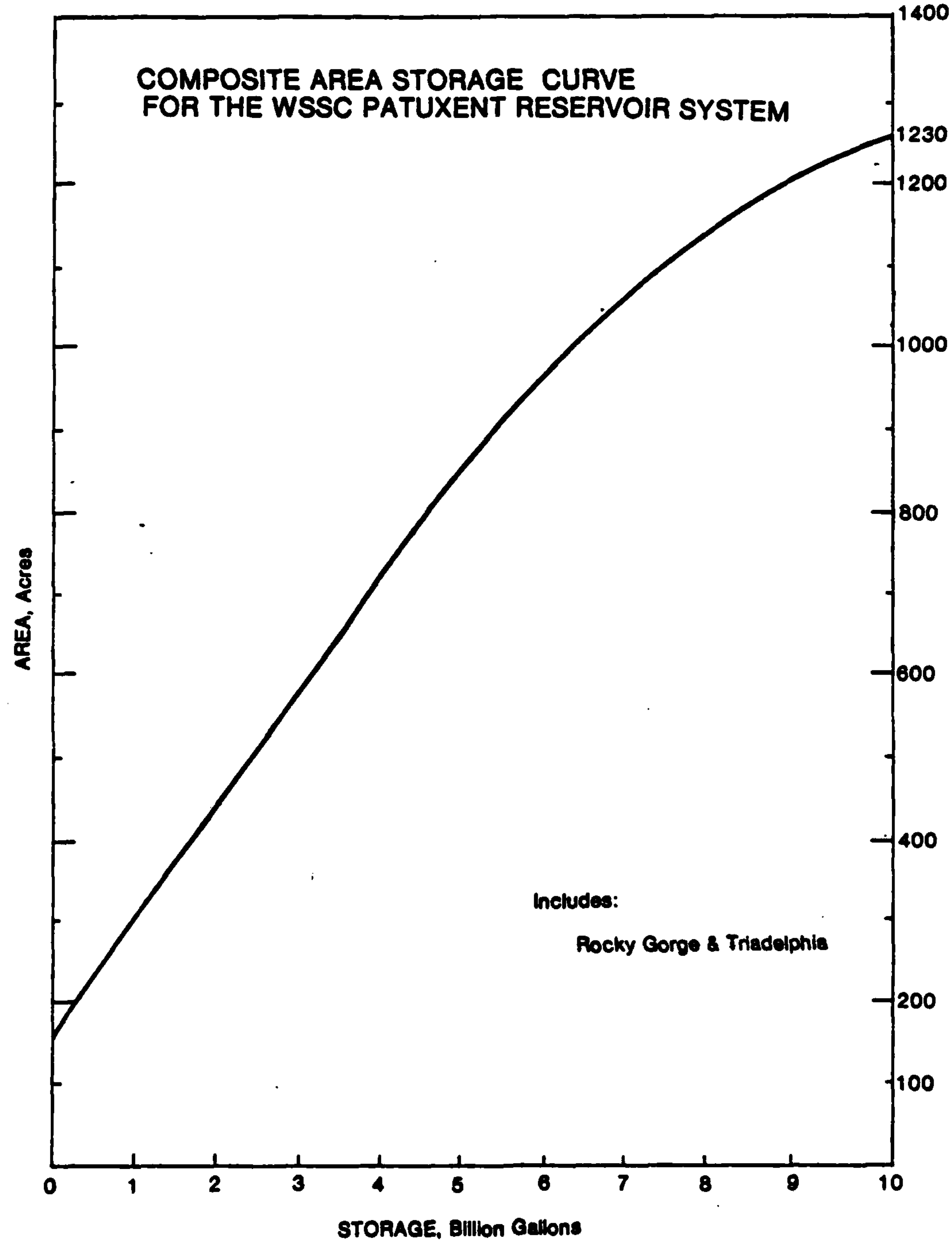
Source: Developed from measurements made by National Weather Service, 29 years of record at Beltsville, Maryland, by Washington Council of Government, 1977.

Figure E-31



COMPOSITE AREA STORAGE CURVE
FOR THE OCCOQUAN RESERVOIR
3000
2500
2000
1500
1000
500
AREA, Acres
2
4
6
8
10
STORAGE, Billion Gallons

Figure E-32



COMPOSITE AREA STORAGE CURVE
FOR THE WSSC PATUXENT RESERVOIR SYSTEM
AREA, Acres
1400
1230
1200
1000
800
600
400
200
100
Includes:
Rocky Gorge & Triadelphia
0
1
2
3
4
5
6
7
8
9
10
STORAGE, Billion Gallons

Figure E-33

The major assumptions used in the development of the reregulation operating rule are listed below:

1. 100 mgd is the amount of flow into the estuary.

2. The existing WSSC and FCWA reservoir can be operated at the minimal levels as previously specified (Patuxent - 20 mgd; Occoquan - 30 mgd).

3. Baseline average monthly demands are used as developed in the Appendix D - Supplies, Demands, and Deficits.

Three additional statements are needed before stating the operating rule. First, since the WSSC Patuxent treatment plant can provide water less expensively than the Potomac plant (this is due to lower treatment and pumping costs), the reservoir treatment plant was assumed to operate at a capacity equal to the inflow to the reservoir. When the Patuxent Reservoirs are full, of course, this operating value cannot go below the previously assumed minimum operating level of 20 mgd. Secondly, it was assumed that FCWA would rather use its capacity on the Occoquan as its top priority when its reservoir is full. The last consideration is how to allocate excess Potomac River flow between these two water service areas when the Low Flow Allocation Agreement (LFAA) is in effect. In the event that the reader is unfamiliar with the theory of the LFAA and its allocation rule, please refer to the Appendix D for a more detailed explanation. When examining the LFAA, it is found that there is no clear indication of how much of the "excess" water is available for reallocation or how it is to be reallocated. The LFAA states only the following: "In the event the applicable allocation formula results in an allocation exceeding the proposed withdrawal of any user, the excess amount shall be reported by said user to the Aqueduct for reallocation." Nonetheless, reallocation of this excess is critical to efficient operation of the area's water utilities.

Because there is no approved method of allocating "excess" water, a rule was developed which allocates the excess such that withdrawals from the Occoquan Reservoir are approximately 150 percent of the withdrawal from the Patuxent Reservoir during the restriction or emergency stages of the LFAA. While this is not the only rule which could be used, it is sufficient to meet demands during droughts and has the following advantages: (1) withdrawals are kept, as much as possible, proportionate to the safe yields of the reservoirs, reducing the likelihood of one reservoir going dry while the other is not; (2) withdrawals are also proportionate to the treatment capacity at the reservoirs; and (3) operation under this rule is consistent with the general provisions of the existing LFAA.

OPERATING RULES

Presented below are the monthly flow operational rules developed for the reregulation scheme. These rules have been divided into seven cases as follows:

Case I IF: Both reservoirs are full with adequate flow in the Potomac, and inflow to each reservoir is greater than withdrawals (sum of demands plus evaporation losses plus downstream releases),

THEN: Patuxent WTP "Q_p" is operated at 40 mgd (.75 x 65 mgd) and remainder of WSSC demand is made up from Potomac. Occoquan WTP "Q_o" is operated at 69 mgd and remainder of FCWA is made up from Potomac.

$$Q_p = 49 \text{ and } Q_o = 69$$

Case II IF: Both reservoirs are full with adequate flow in the Potomac, but inflow to either reservoir is less than the desired withdrawal rate as specified in Case I,

THEN: Patuxent WTP is operated at a rate so reservoir just stays full (Q_p = Inflow - Evaporation - Downstream Releases), but never less than 20 mgd. Remainder of WSSC demand is made up from Potomac. Occoquan WTP is also operated at a rate so reservoir just stays full (Q_o = Inflow + STP (Sewage Treatment Plant anticipated from the Upper Occoquan Sewage Authority Treatment Plant located upstream of the Reservoir) - Evaporation), but never less than 30 mgd. Remainder of FCWA demand is made up from Potomac.

$$20 \leq Q_p \leq 49$$
$$30 \leq Q_o \leq 69$$

Case III IF: Patuxent is full, Occoquan is not full, adequate water in Potomac, but inflow to either reservoir is less than desired withdrawal rate as specified in Case I,

THEN: Operate Patuxent WTP as in Case II. Operate Occoquan WTP at 30 mgd.

$$20 \leq Q_p \leq 49$$
$$Q_o = 30 \text{ mgd}$$

Case IV IF: Occoquan is full, Patuxent is not full, adequate water in Potomac, but inflow to either reservoir is less than desired withdrawal rate as specified in Case I,

THEN: Operate Patuxent WTP at 20 mgd. Operate Occoquan WTP as in Case II.

$$Q_p = 20$$
$$30 \leq Q_o \leq 69$$

Case V IF: Neither reservoir is full, but there is adequate flow in the Potomac,

THEN: Patuxent WTP is operated at a minimum of 20 mgd and Occoquan WTP is operated at a minimum of 30 mgd. All remaining demands are met from the Potomac.

$$Q_p = 20 \text{ mgd}$$
$$Q_o = 30 \text{ mgd}$$

Case VI IF: Neither reservoir is full and there is not sufficient water in the Potomac to meet projected Potomac withdrawals, but there is sufficient capacity at the reservoir WTP's to meet the unmet demands,

THEN: 100 mgd is retained in the Potomac for flowby, WAD and Rockville demands are met from the Potomac. The remainder of the Potomac flows are divided between FCWA and WSSC such that the withdrawal from the Occoquan is approximately 1.5 times the withdrawal from the Patuxent.

$$Q_o = 1.5\,Q_p \qquad \begin{array}{l} Q_o \text{ max} = 84 = (.75 \times 112 \text{ mgd}) \\ Q_p \text{ max} = 49 = (.75 \times 65 \text{ mgd}) \end{array}$$

Case VII IF: Neither reservoir is full and there is some Potomac flow and the maximum output of reservoir WTP will not meet demands,

THEN: 100 mgd is retained in the Potomac for flowby, and the LFAA formula is used to allocate flows to the different users. The Occoquan and Patuxent WTP's are operated at their maximum capacities of 84 and 49 mgd, respectively.

$$Q_o = 84$$
$$Q_p = 49$$

MONTHLY DROUGHT SIMULATION

To illustrate these operation rules, Table E-48 shows the average monthly simulation of the reregulation component using the 1930-1932 drought condition and the year 2030 baseline projected average monthly demands. The table "tracks" the effects of reservoir and river withdrawals, reservoir inflows, evaporation, and downstream releases and indicates the remaining storage and river flows at the end of each month. The base Potomac River flow was taken from USGS gaging station data for the (adjusted) Washington, DC gage.

Figure E-34 graphically illustrates the effects of reregulation on the Potomac River and the Patuxent and Occoquan Reservoir storage levels. The solid line represents the flows in the Potomac and the reservoir levels that would occur under the "without condition" (reregulation not in effect). Superimposed upon this is the conditions that would exist if reregulation (represented by the dashed line) was implemented. As can be seen, the savings in storage that could be realized on the Occoquan Reservoir for example, if the reregulation concept was implemented would be 0.9 billion gallons of water in the month of August. The values used to generate these curves are listed in Table E-48.

ENVIRONMENTAL ANALYSIS

Due to the non-structural nature of reregulation, the following discussion is limited to operational impacts. The basic premise behind reregulation assumes that during high flow conditions in the Potomac River, withdrawals from the area's offstream storage sites decrease. As a result, during the greater portion of a given year, healthier conditions would persist in the reservoirs due to the increased volume in storage.

However, during critical shortages, for example, the system would be operated differently. In these cases, stored water that has accumulated over time is now needed in greater proportions because of low flow conditions in the Potomac River. To offset this situation, reregulation would operate toward averting shortages by increasing withdrawals on the reservoirs, thereby causing in some cases greater drawdowns than would otherwise be expected. If rapid reservoir drawdown should occur during the spawning period (April - early July), fish populations may be greatly reduced. In addition, water based recreational activities such as boating and fishing would be adversely affected.

CONCLUSIONS

In addition to showing that the reregulation component alone can provide an adequate yield in both the reservoirs through the year 2030 to meet 30-day demands, several additional general conclusions can be drawn from the analysis. These conclusions are stated as follows:

1. Reregulation allows for the maximum use of available storage capacity by reducing withdrawals from the reservoirs and drawing excess water from the Potomac River during noncritical periods of flow.

2. The WSSC and the FCWA water service areas directly benefit from the reregulation alternative. While the WSSC system is presently operational to benefit immediately from a reregulation schedule, the FCWA could only benefit after the new FCWA Potomac River treatment plant is operational and after other minor improvements are made to its distribution system.

3. Reregulation makes maximum use of existing facilities and requires a minimum amount of structural modification. For this reason, it is a potentially effective alternative that can be implemented for a relatively low cost and provides little or no adverse constructional impacts,

4. Reregulation is flexible in that it can be implemented on an as needed basis; however, it could provide maximum benefit if operated on a continuous yearly basis.

5. Reregulation is not suited to meet water supply needs for peak (one or seven-day duration) demands, since by principle it saves small amounts of water over a long period of time.

6. Reregulation allows the downstream water suppliers, who rely solely on the Potomac River for nearly all of their available supply (e.g., Rockville and WAD water service areas), to benefit because there is a net reduction of Potomac River upstream withdrawals by WSSC and FCWA allowing more water in the river.

TABLE E-48
REREGULATION ANALYSIS DATA

Year 2030
No Action Plan, with Baseline Conservation & Reregulation **30 Day Analysis, 1930-1932 Drought**

	Apr 1930	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan 1931
CASE NUMBER	I	II	II	II	VII	VI	VI	V	V	V
Potomac Flow @ Little Falls (MGD)	6153	2780	2052	1016	570	641	563	654	1,319	2,154
Bloomington Releases (MGD)				60	135	135	135	75		
Potomac Plus Bloomington (MGD)	6153	2780	2052	1076	705	776	698	729	1,319	2,154
WAD & Rockville Demands	234	247	276	300	286	277	253	238	232	230
WSSC Demands	266	297	338	344	327	327	282	263	258	253
FCWA Demands	142	156	170	184	175	165	148	140	138	131
Total Demands	642	700	784	828	788	769	683	641	628	614
Patuxent Inflows (MGD)	105	40	30	14	7	6	7	13	25	34
Patuxent Evaporation (MGD)	-4	-4	-5	-6	-5	-3	-2	-1	0	-1
Patuxent Releases (MGD)	-11	-11	-11	-11	-7	-6	-7	-11	-11	-11
Patuxent Demands (MGD)	-49	-33	-20	-20	-49	-37	-38	-20	-20	-20
Net Inflow (MGD) 10-11-12-13	+41	0	-6	-23	-56	-40	-40	-19	-6	+2
Inflow Volume (MG) x # days/month	+1,230	0	-180	-713	-1,736	1,200	-1,240	-570	-186	+62
End of Month Storage (MG) 10,100 MG	10,100	10,009	9,920	9,207	7,471	6,271	5,071	4,501	4,315	4,377
Occoquan Inflows (MGD)	315	127	89	21	3	3	4	6	39	61
Occoquan STP Inflows (MGD)	+10	+11	+12	+13	+12	+12	+11	+10	+10	+9
Occoquan Evaporation	-5	-6	-7	-8	-7	-4	-2	-1	0	-1
Occoquan Demands (MGD)	-69	-69	-84	-30	-84	-58	-57	-30	-30	-30
Net Inflow (MGD) 18-19-20-21	+251	+63	0	-4	-76	-46	-44	-15	+19	+39
Inflow Volume (MG) x # days/months	+7,530	+1,953	0	-124	-2,356	1,350	-1,364	-450	+589	1,209
End of Month Storage (MG) 10, 200 MG	10,200	10,200	10,200	10,076	7,720	6,370	5,006	4,556	5,145	6,354
Potomac Summary						277	253	238	232	230
WAD & Rock Demands	234	247	276	300	286	280	244	243	238	233
WSSC (8-13) Demands	217	264	318	324	278	109	91	110	108	101
FCWA (7-20) Demands	73	87	108	154	91	678	588	591	578	594
Total Potomac Demands	524	598	700	778	655					
					(805)	100	100	138	741	1,590
Remaining Flow in Potomac	5,629	2,182	1,352	300	100					
					60 mgd shortage					

	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
CASE NUMBER	V	V	IV	IV	IV	IV	IV	IV	IV	V	V	V	IV	IV	IV	I
Potomac Flow @ Little Falls (MGD)	2,582	4,385	10,503	9,477	4,415	4,316	3,059	1,826	1,079	803	1,937	4,564	7,903	11,032	11,568	18,097
Bloomington Releases (MGD)						60	135	135	135	75						
Potomac Plus Bloomington (MGD)	2,582	4,385	10,503	9,477	4,415	4,376	3,194	1,921	1,214	878	1,937	4,564	7,903	11,032	11,568	18,097
WAD & Rockville Demands	229	224	234	247	276	300	286	277	253	238	232	230	229	224	234	247
WSSC Demands	253	253	266	297	338	344	327	327	282	263	258	253	253	253	266	297
FCWA Demands	131	131	142	158	170	184	175	165	148	140	138	131	131	131	142	158
Total Demands	613	608	642	700	784	828	788	769	683	641	628	614	613	608	642	700
Patuxent Inflows (MGD)	25	43	49	42	41	68	54	14	11	14	24	61	59	83	78	90
Patuxent Evaporation (MGD)	-1	-2	-2	-3	-4	-5	-4	-3	-2	-1	0	-1	-1	-2	-3	-4
Patuxent Releases (MGD)	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
Patuxent Demands (MGD)	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-49
Net Inflow (MGD) 10-11-12-13	-7	+10	+16	+8	+6	+32	+18	-20	-22	-18	-7	+29	+27	+50	+44	+26
Inflow Volume (MG) x # days/month	-196	+310	+480	+248	+180	+992	+558	-600	-682	-540	-217	+899	+756	-1,550	+1,320	+806
End of Month Storage (MG) 10,100 MG	4,181	4,491	4,971	5,219	5,399	6,397	6,980	6,380	5,698	5,158	4,941	5,840	6,596	6,146	9,466	10,100
Occoquan Inflows (MGD)	34	97	179	131	78	60	60	31	9	13	30	172	203	568	310	325
Occoquan STP Inflows (MGD)	+9	+9	+10	+11	+12	+13	+12	+12	+11	+10	+10	+9	+9	+9	+10	+11
Occoquan Evaporation	-2	-3	-4	-6	-7	-8	-7	-5	-3	-2	0	-2	-3	-4	-5	-6
Occoquan Demands (MGD)	-30	-30	-69	-69	-69	-65	-65	-38	-30	-30	-30	-69	-69	-69	-69	-69
Net Inflow (MGD) 18-19-20-21	+11	+73	+116	+67	+12	0	0	0	-13	-9	+10	+110	+140	+504	+246	+261
Inflow Volume (MG) x # days/months	+308	+2,263	+3,480	+2,077	+360	0	0	0	-403	-270	+310	+3,410	+3,920	+15,624	+7,380	+8,091
End of Month Storage (MG) 10, 200 MG	6,662	8,925	10,200	10,200	10,200	10,200	10,200	10,200	9,797	9,527	9,837	10,200	10,200	10,200	10,200	10,200
Potomac Summary	229	224	234	247	276	300	286	277	253	238	232	230	229	224	234	247
WAD & Rock Demands	233	203	248	277	318	324	307	307	282	243	238	233	233	233	246	248
WSSC (8-13) Demands	101	101	73	87	101	119	110	127	118	110	108	62	62	62	73	87
FCWA (7-20) Demands	583	558	553	611	695	743	713	711	633	591	578	525	524	519	553	582
Total Potomac Demands																
	2,029	3,827	9,950	8,866	3,720	3,573	2,481	1,210	581	267	1,359	4,039	7,379	10,513	11,015	17,515
Remaining Flow in Potomac																

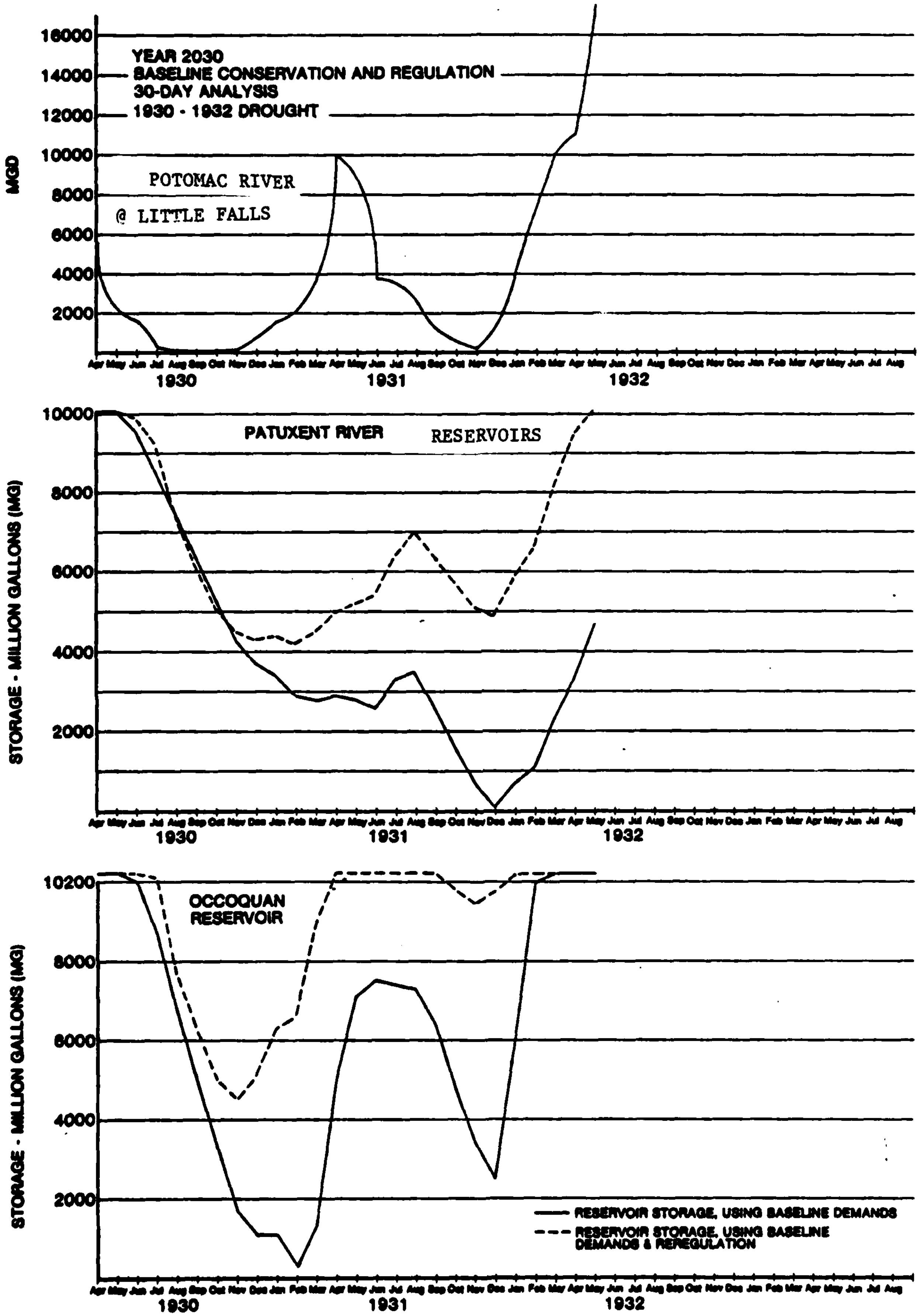

YEAR 2030
BASELINE CONSERVATION AND REGULATION
30-DAY ANALYSIS
1930 - 1932 DROUGHT
MGD
POTOMAC RIVER
@ LITTLE FALLS
16000
14000
12000
10000
8000
6000
4000
2000
1930
1931
1932
STORAGE - MILLION GALLONS (MG)
PATUXENT RIVER
RESERVOIRS
10000
8000
6000
4000
2000
1930
1931
1932
STORAGE - MILLION GALLONS (MG)
OCCOQUAN RESERVOIR
10200
8000
6000
4000
2000
RESERVOIR STORAGE, USING BASELINE DEMANDS
RESERVOIR STORAGE, USING BASELINE DEMANDS & REREGULATION
1930
1931
1932

Figure E-34

ANNEX E-I

SPECIAL INVESTIGATION

OCCOQUAN INTERCONNECTION COMPARISON

ANNEX E-1

SPECIAL INVESTIGATION

OCCOQUAN INTERCONNECTION COMPARISON

The Commonwealth of Virginia requested the Corps of Engineers to investigate several raw water interconnections to the Occoquan watershed: Shenandoah to Broad Run, Potomac to Cub Run, and Potomac to Occoquan Reservoir. Figure E-I-1 shows a schematic of the Occoquan River Basin and the Occoquan raw water interconnections analyzed.

Initially, the Corps investigated only one-way pipelines from the river source to the reservoir watershed. FCWA, however, pointed out that merely providing additional water to the Occoquan Reservoir would not help to meet peak demands, because the system would be constrained by the water treatment plant capacity at the Occoquan Water Treatment Plant (WTP). In the year 2030, FCWA would need about 70 mgd more water than would be available from both the Occoquan WTP and the allocated share of the Potomac River at historic 7-day duration low flows. To provide this extra treatment capacity, it would be necessary either to provide an additional Occoquan WTP by use of an interconnection (which would have excess capacity when Potomac flows are low). Five alternates were investigated to provide FCWA with the required storage and WTP capacity to meet the need for 70 mgd more of treated water. These alternatives are listed in Table E-I-1 along with preliminary estimated costs. All pipeline and pump station costs were developed based on engineering and cost data developed by Hayes, Seay, Mattern and Mattern in their report entitled "Development of Engineering and Cost Data for Raw and Finished Water Interconnections", April 1979, as part of the Metropolitan Washington Area Water Supply Study. Costs for the 70 mgd increase to the Occoquan WTP were obtained from a curve developed by the firm of Henningson, Durham, and Richardson for the Bi-County Water Supply Task Force Report, March 1978. All costs were updated to October 1981 by the Engineering News Record Construction Cost Index.

In addition to a comparison of pipe and WTP expansion costs, several other observations could be made. The intention of FCWA to add two feet of storage to the Occoquan Reservoir lessened the need for supplemental flow to the Reservoir. (This 2-foot addition has since been made). The primary problem of FCWA will be the need to furnish additional water to the Potomac service area when Potomac flows are low. Alternatives 1 & 2 do not include substantial (undeterminable) costs of required improvements to the FCWA finished water distribution system in order to have the distribution network function as proposed. Alternative 1 & 2 would also be putting water into the system in the southeastern section of the service area, whereas most new growth is projected for the northwestern section of FCWA (to be served from the Potomac). Thus additional pumping costs would be felt in these cases. There would also be a question of interbasin transfer of water with either Alternative 1 or 2. Alternatives 4 & 5 would require the construction of two long pipelines, and the environmental and social impacts would be greater than the Alternative 3, which would construct only 1 pipeline but with extra pumps for reverse flow. Alternative 4 and 5 would also be concerned with the question of interbasin transfer of water, only Alternative 3 would not be affected.

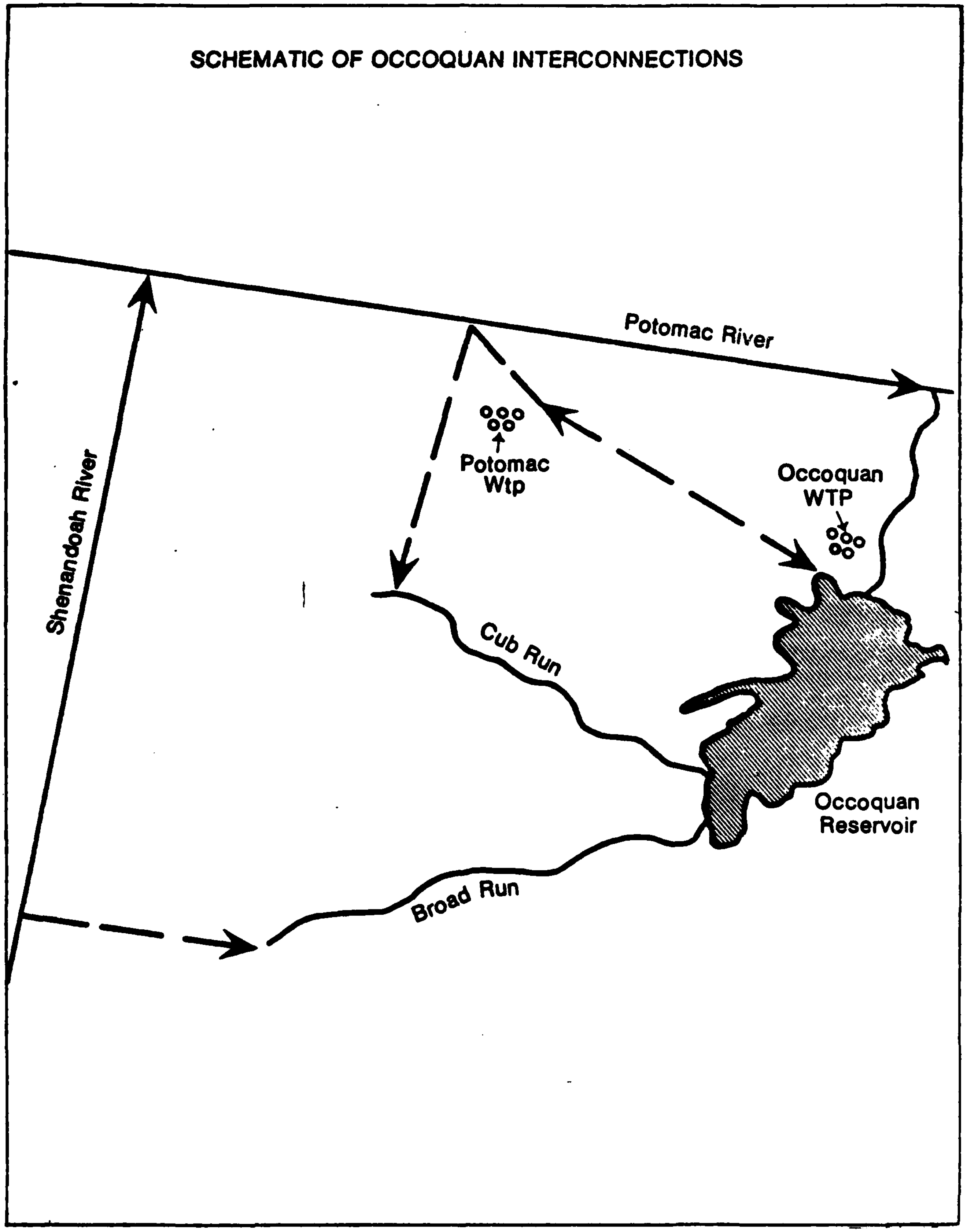

SCHEMATIC OF OCCOQUAN INTERCONNECTIONS
Potomac River
Shenandoah River
Potomac
Wtp
Occoquan
WTP
Cub Run
Occoquan
Reservoir
Broad Run

Figure E-I-1

TABLE E-I-1

COMPARISON OF OCCOQUAN INTERCONNECTION ALTERNATIVES
FINAL COST ESTIMATES
(October 1981 Prices)

<u>Alternate #1</u>

a)	Shenandoah to Broad Run 1-way RWI (50 mgd)	
	Pipeline Cost	$33,792,000
	Pump Station Cost (including river intake)	6,400,000
	Land Cost	10,240,000
	Subtotal	$50,432,000
b)	Additional capacity at Occoquan WTP (70 mgd)	62,720,000
	TOTAL PROJECT COST	$113,152,000

<u>Alternate #2</u>

a)	Potomac to Cub Run 1-way RWI (50 mgd)	
	Pipeline Cost	$21,376,000
	Pump Station Cost	4,480,000
	Land Cost	8,960,000
	Subtotal	$34,816,000
b)	Additional capacity of Occoquan WTP (70 mgd)	62,720,000
	TOTAL PROJECT COST	$97,536,000

<u>Alternate #3</u>

a)	Potomac to Occoquan 2-way RWI (70 mgd)	
	Pipeline Cost	$56,576,000
	Pump Station Cost	10,368,000
	Land Cost	14,080,000
	Subtotal	$81,024,000
b)	No new capacity at Occoquan WTP	0
	TOTAL PROJECT COST	$81,024,000

TABLE E-I-1 (continued)

COMPARISON OF OCCOQUAN INTERCONNECTION ALTERNATES
FINAL COST ESTIMATES
(October 1981 Prices)

Alternate #4

a) Potomac to Cub Run 1-way RWI (50 mgd)

Pipeline Cost	$21,376,000
Pump Station Cost	4,480,000
Land Cost	8,960,000
Subtotal	$34,816,000

b) Occoquan to Potomac 1-way RWI (70 mgd)

Pipeline Cost	$56,576
Pump Station Cost	4,096
Land Cost	14,080
TOTAL PROJECT COST	$74,752,000

Alternate #5

a) Shenandoah to Broad Run 1-way RWI (50 mgd)

Pipeline Cost	$33,792,000
Pump Station Cost	6,400,000
Land Cost	10,240,000
Subtotal	$50,432,000

b) Occoquan to Potomac 1-way RWI (70 mgd)

Pipeline Cost	$56,576,000
Pump Station Cost	4,096,000
Land Cost	14,080,000
TOTAL PROJECT COST	$74,752,000

Additionally, Alternative 3 would provide a great deal of flexibility in meeting FCWA's needs. It could be used to fill the Occoquan Reservoir; or if interbasin transfers are a problem as mentioned above, water could be transferred from the Potomac directly to the Occoquan WTP, thereby reducing the draft on the Reservoir. In times of shortage on the Potomac River, water would be pumped from the Reservoir to the Potomac WTP. Once treated, the water would be in the general vicinity of where it would be most needed. Finally, the reversible pipeline between the Potomac and the Occoquan would also add to the region's flexibility in meeting peak day shortages on the Potomac River.

END

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